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Metacognition and meteorology: using reflective thinking strategies to help novice weather forecasters adopt effective forecasting strategies

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Metacognition and meteorology: Using reflective thinking strategies to help novice weather forecasters adopt effective forecasting strategies

by

Jeffrey Michael Kenton

**A dissertation submitted to the graduate faculty
in partial fulfillment of the requirements for the degree of
DOCTOR OF PHILOSOPHY**

Major: Education (Curriculum and Instructional Technology)

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2002

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ABSTRACT

This dissertation contains two papers that investigate the use of metacognitive learning and thinking strategies with university-aged students learning science. The first paper reviews studies that have focused on the instructional implications of using metacognitive teaching and learning strategies in the classroom. Metacognition has been researched extensively in specific domains (such as reading) and with predominately young children. Lately, the value of metacognitive strategies has begun to be investigated in other cognitive domains (such as math and science) and with older students. The review paper ends with a suggestion for further research, extending the scope of metacognition to even broader areas.

The second paper reports a case study of eleven students' use of metacognitive processes in a technology-enhanced introductory meteorology course. The study analyzed how novices engaging in metacognitive activities monitored and changed personal conceptions about weather processes and how they used those conceptions to write forecasts. Among the eleven students, several different metacognitive approaches to forecasting were employed. Several students changed their metacognitive approaches during the study. The journaling activities, interviews and other metacognitive thinking prompts probably contributed to improvements of metacognitive processes. Some suggestions for further research and practice in the area of metacognition with college-aged students learning about science are also included.

CHAPTER 1. INTRODUCTION

Learning about science is often one of the hardest things that students have to do while enrolled in school (e.g. Chi, 1992; Slotta, Chi & Joram, 1995). One reason for this difficulty may be that students are often expected to learn science by memorizing details that researchers took years to develop and determine. Furthermore, these details are often very difficult to reconcile with existing ideas about the underlying physical processes that students may have developed in informal or out of school environments (e.g. Hewson, 1982; Posner, Strike, Hewson & Gertzog, 1982).

It has become clear in recent years that students don't always respond to memorization and the rote application of formulas to solving problems (e.g. Cognition and Technology Group at Vanderbilt, 1992; Sternberg, 1998). Some students learn better following a laboratory manual and completing experiments. Other students prefer to learn using visual methods like watching experiments carried out on video, still others learn best when creating and completing their own experiments with science. In other words, students have extremely individual learning preferences that cannot always be addressed using a single instructional method. However, the prospect of developing individual lesson plans and learning strategies for each student in a classroom is also extremely difficult to achieve.

Metacognition is a collection of cognitive processes that has been described by a group of theories. In its simplest definition, metacognition is described as "thinking about thinking." However, breaking the word down to its suffix meta- and its root cognition, suggests that metacognition is more properly described as a process that has a transcending or superordinate relationship to the processes known as cognition. From that standpoint,

metacognition informs all manner of thinking from problem identification through solution strategy selection and cognitive implementation of the solution strategy.

John Flavell in the early 1970's suggested the term metacognition as an organizational description of two disparate thinking processes. Flavell suggested that metacognition combined metamemory and metacomprehension. Metamemory is an individual's personal set of cognitive thinking strategies, while metacomprehension is an individual's personal set of strategy selection strategies. For example, if a person determines that a problem resides in the field of science, that person would use metacomprehension to identify which strategies in his metamemory are the most appropriate to apply toward solving the problem.

Many studies using metacognition have been completed in the fields of elementary reading and mathematics. Several studies using metacognition and epistemology have been completed in the field of secondary science and with small groups of students learning science at the university level. Very few, if any, studies using metacognitive learning and thinking strategies have been performed within university classrooms that have more than 100 students. The purpose of this dissertation is to review the current relevant literature on metacognition and metacognition in science education, and to report a study concerned with novices enrolled in an introductory meteorology course with more than 100 students. The study analyzed how students used reflective thinking methods to modify their conceptions about weather forecasting and how the students used reflective thinking strategies to change their weather forecasting strategies. The dissertation's four chapters are organized in the following way: Chapter 2 contains a review paper summarizing the development of a theory of metacognition and its use in educational settings, especially in science education. Chapter 2 is formatted as an article for publication in a journal relating to research in science

education; Chapter 3 contains a report of a study completed with students enrolled in a large lecture format university course on meteorology. The study investigated the use of metacognitive thinking prompts and their effect upon students' conceptions about weather forecasting, and using those conceptions to write accurate forecasts.; Chapter 4 contains a general summary and set of conclusions about the study's findings and suggestions for future research in the area of science education with metacognitive thinking prompts.

CHAPTER 2. SOME FACTORS INFORMING THE USE OF METACOGNITIVE LEARNING AND TEACHING STRATEGIES IN THE CLASSROOM: A REVIEW

A paper to be submitted to the Review of Education Research

Jeffrey M. Kenton

Abstract

This paper reviews several studies that have focused on the instructional implications of using metacognitive teaching and learning strategies in the classroom. Metacognition has been researched extensively in specific domains (such as reading) and predominately with young children. Lately, the value of metacognitive strategies has begun to be investigated in other cognitive domains (such as math and science) and with older students. The studies cited in this review attempt to show the various factors that are involved in making the decision to teach metacognitively, or to teach how to think metacognitively. For example: Are metacognitive skills specific to a particular context or are they generally applicable mental skills; Are some students more able to engage in metacognition due to initial differences in cognitive ability?; Does the level of metacognitive ability of the instructor play a role? The review ends with a suggestion for further research, extending the scope of metacognition to even broader areas.

Introduction

One assumption about traditional instructional techniques is that learners will take in information presented by lecture, process it further on their own and arrive at the end of the course with a somewhat organized understanding of the content being studied. There are two

basic assumptions that support this belief: all students learn, explore and retain in the same way, and; all transmission media are equally able to communicate information and induce the same brain experiences in all recipients. Within university-level science instruction, similar assumptions are made, primarily in courses designed for incoming students. That is, introductory science courses are typically offered to lecture halls filled with students fresh out of high school. If the aforementioned assumption is true, then students who perform poorly in such introductory science courses are probably unsuited for advanced learning in science, and should be encouraged to find careers in different fields. On the other side of this assumption, students who perform well in introductory science courses should be encouraged to pursue careers in science, because it is clear that they are “good at it.”

However, this view of formal science instruction is crumbling under the influence of several factors. These factors include reports indicating that students express personal understanding of science in different ways (Cognition and Technology Group at Vanderbilt, 1992; Sternberg, 1998), that students learn about science in different ways (Chi, 1992; Hewson & Hewson, 1984) and that students use prior knowledge about science differently (Blank, 2000; Perkins, 1992). Student prior knowledge may be full of inconsistencies and misconceptions, which are often not addressed directly using traditional methods (Blank, 2000; Otero, 1998; Posner, Strike, Hewson & Gertzog, 1982). Furthermore, some students are able to better express their understanding by completing non-standard assignments (Cognition Technology Group, 1992), or by completing tasks in rich and complex contexts (Bransford, Sherwood, Hasselbring, Kinzer & Williams, 1990; Duffy & Bednar, 1992). As beliefs about the importance of student differences gain acceptance, a clearer and more

faithful representation of what students really understand about science may be captured (Duffy & Bednar, 1992).

Metacognition is a categorical name given to a set of thinking processes and strategies which have been explored and described in several contexts (Flavell, 1971, 1976, 1979). The term “metacognition” was coined by Flavell in the 1970s to provide an overarching reference point for describing specific types of personal cognitive processes that shape and control individuals’ thinking based upon pre-existing knowledge or beliefs about cognition. Some of the concepts that are included in a definition of metacognition are: strategy creation (Schraw & Moshman, 1995); strategy awareness (Brown, 1978; Flavell, 1979; Kluwe, 1982); strategy refinement (Kluwe, 1982); and strategy monitoring (Dunlosky, 1998; Garner, 1990; Kluwe, 1982; Otero, 1998).

As a classroom full of students encounters a new phenomenon, metacognition may be occurring at many levels. That is, when given a problem to solve, some students may be creating a solution strategy, other students may be refining an existing strategy, and still other students may be deciding which strategy of many to use to solve the problem. Actively monitoring students’ experiences with a new or unfamiliar phenomenon can give some clues to the instructor about how students are analyzing the problem, and whether any students are using metacognitive learning strategies to analyze the problem. For example, an instructor may encourage students to get into small discussion groups or write descriptions of their current ideas to gather some information about how the students are analyzing the new phenomenon (Blank, 2000).

The purpose of this paper is to review the existing literature on metacognition and to construct a description of the current level of understanding of its instructional use and value in the science classroom.

Metacognition

The question of cognitive ability and why people learn has been an enigma for centuries. At the center of this enigma is the question, “Why do people learn, and how do people know when they should know more?” As an example, I offer the following response by Socrates to Meno’s question in Plato’s *Meno*:

“...(M)an cannot inquire either about that which he knows or about that which he does not know; for if he knows, he has no need to inquire; and if not, he cannot; for he does not know the very subject about which he is to inquire.”

At the very root of this statement are several assumptions about how knowledge may be transmitted from expert instructor source to novice pupil. For example, Plato believed that learners could not directly experience reality because the objects that could be sensed were merely representations of perfect, immutable Forms. These ideal Forms are the basis upon which a dynamic assortment of physical entities can exist. For example, while the physical tree can be destroyed by physical means or wither and die of natural causes, the Form of a tree cannot be assailed. That is, the tree that exists in our sensory world is merely a representation of the perfect, unchanging, undying Tree Form. Following this belief, Plato described humans as beings viewing the shadows of Forms cast by the Truth upon a cave wall, from which we are powerless to divert our gaze.

Plato also believed that humans were born with an innate knowledge of all Forms. The process of education was thus one of extracting an understanding of the Forms from the

individual. The process of recalling knowledge from the innate stores required much effort and was facilitated by the intervention of a learned advisor. The role of the advisor was to bring the understanding to light through questioning or dialog.

Plato's beliefs would make him an Idealist in today's verbage. That is, he believed in the existence of a single Truth, which humans are striving to understand. However, because we are only able to view the "shadows" of the Forms, and not the forms themselves, we can only develop imperfect understandings of the Forms. Thus, our understanding of the Truth would always remain somewhat indeterminate.

Much later, British empiricists developed the concept of the *Tabula rasa* (blank tablet) to describe undeveloped learners' minds (for more about the concept of the tabula rasa and empiricism, see *The Great Psychologists, 1963*). One of the British empiricists was John Locke (1632 – 1704). Instead of the *tabula rasa*, Locke used the metaphor of an "empty cabinet" to represent the undeveloped learner's mind. Such a belief stood in opposition to Plato's belief that knowledge about the Truth (through Forms) was innate. Locke suggested that individuals "stocked" their cabinet with many and varied lifelong experiences. Only as the learner grew older and accumulated more contents in the cabinet, could the process of reflection help to refine the experiences into more coherent sets. Unlike post-positivists, empiricists believe in the ability of humans to perfectly understand the single universal truth. Thus by using perfect methods, a learner would gradually be able to develop a perfect understanding of the world around her.

The previous two examples of cognitive theories have assumed that learning is the process of coming to understand the single, external, fixed reality. Whether the learner must toil hard to uncover an innate understanding of Truth (ala Plato), or use a lifetime of

experiences to refine a personal understanding of the Truth (ala empiricism), both processes appear to be steered and judged by individual learners and are based upon personal understandings of only indirectly knowable truths. That is, the learner is constantly compelled to adjust and align personal beliefs to synchronize them with universal truths in absence of the ability to directly view or manipulate the truths themselves.

Metacognition has its roots deeply entrenched in the works of theorists concerned with the cognitive processes individuals use to acquire and modify personal understandings. That is, metacognition researchers are less concerned with the end result of cognition and more concerned with understanding and describing the thinking processes used by learners. Among these theorists are John Dewey, Jean Piaget and Lev Vygotsky. While none of these theorists spoke specifically about something called “metacognition,” Dewey’s *Reflective Thinking* (1910), Vygotsky’s *Zone of Proximal Development* (1978) and Piaget’s *Stages of Development* (1952; Inhelder and Piaget, 1958) seem to share several traits with the current theories describing metacognition.

The works of Dewey, Vygotsky and Piaget agree that knowledge is both constructed by the learner, and is influenced by various factors. However, each of these theorists described the level of control learners have over their cognitive development in different ways. Vygotsky’s theories emphasized the social influences present in individual cognition such as between a master and an apprentice (1978). Piaget’s theories more closely scrutinized the individual’s control of personal cognitive processes within peer-to-peer relationships (1952; Inhelder & Piaget, 1958). Dewey’s theories were more general in scope and tended to include descriptions of how education and experiences can act to help develop personal

cognitive abilities, while at the same time passing on institutional and social mores to individuals (Dewey, 1916;1938).

All three of these theorists agreed that learners were able to make judgments about what they correctly understood or did not understand. With this knowledge, all three suggested that learners could reconcile their beliefs based upon local understandings of the truth, rather than merely aligning personal theories with an invariable truth. Developing a personal ability to better understand their environs required learners to closely monitor and make changes to their current personal understandings, when necessary.

The term “metacognition” was coined by Flavell to describe a number of processes learners use when thinking. Flavell defined metacognition as: “one’s knowledge concerning one’s own cognitive processes and products or anything related to them (1976, p.232).” These cognitive processes include learners developing an awareness of their current set of personal learning strategies, creating new learning strategies, or modifying existing learning strategies when personally-developed strategies failed to accurately propose a solution to a problem. Flavell also provided descriptions of two constructs that appear to be subordinate components of metacognition itself: metacomprehension and metamemory.

Metacomprehension is the process of developing strategies to maximize comprehension. By accentuating the metaconceptual ability of learners, it is assumed that these learners will critically view their own theories as well as those of others (Blank, 2000). That is, once the learner is able to identify flaws in personal theories, and learn that more appropriate theories are available, the door may be open to conceptual change (Mason, 1994). Metamemory is the process of assessing a situation and activating the most suitable strategy for solving a problem, but also includes the ability to realize that there may not be an

appropriate solution strategy available. When students begin to use their metamemory abilities, they can learn to ask questions whose answers will fill some of the existing gaps in their individual understandings (Gavelek & Raphael, 1985; Sternberg, 1998). In other words, metacomprehension represents a learner's composite group of strategies and metamemory represents the learner's ability to discern and enact appropriate strategies in appropriate situations.

More recently, the definition of metacognition has been expanded to include more constructs. The additional concepts help to more fully describe the development of metacognition and metacognitive abilities in learners, as well as providing some examples that help learners develop mature metacognitive abilities. Some of these concepts include: an instructional concern for understanding students' existing abilities or the introductory climate of the classroom (Gavelek & Raphael, 1985); rational reasons for individuals to engage in metacognition (Mason, 1994; Schraw & Moshman, 1995); a differentiation between metacognitive knowledge and metacognitive control processes (Schraw and Moshman, 1995); interpersonal differences in metacognitive activation (Sternberg, 1998), and; identification of various factors that can influence the use of metacognitive learning and thinking strategies (Schoenfeld, 1987; Kuhn, 1999), including learning context and cultural influences (Gavelek & Raphael, 1985; Schraw and Moshman, 1995). The next several sections will provide brief synopses of each of these specific additions.

Introductory Climate

Understanding the current state of a problem is an essential step in determining how to proceed toward a solution. Similarly, instructors must be aware of the existing state of learners' comprehension with regard to a topic before engaging in instructional activities

(Gavelek & Raphael, 1985). Prior knowledge in a field interacts with and affects strategy use in that field (Flower, 1990; Pressley & Afflerbach, 1995; Pressley, Van Etten, Yokoi, Freehorn & Van Meter, 1998). Though determining the level of introductory understanding is the stated purpose of most pre-tests in classroom situations, written examinations do not seem to accurately elicit evidence of metacognitive strategies (Dunlosky, 1998, Gunstone & Gray, 1992).

Relying on simple written recall tests to reveal the details of student understanding (not just comprehension or memory) about a topic after instruction is problematic in other ways (Gunstone & Gray, 1992). For example, the quality of standard instructional activities is currently measured by the difference between scores on pre-tests and post-tests on the same content. The danger in relying solely on subjective results is that often learners and instructors may come away with very different impressions of the effect of instructional activities (Blank, 2000). That is, instructors may develop instructional activities that seem to address areas where students lack understanding, but students may not develop the necessary connections between pre-test levels of understanding and classroom activities to produce an adequate level of post-instructional understanding.

Instead of relying solely on tests of recall to provide evidence of understanding, Gavelek & Raphael (1985) suggest that directed and purposive questioning can better detect a learner's use of metacognitive strategies and thus enable an instructor to gather information about how students are thinking. By analyzing the information gathered from questioning, instructors can characterize the level of understanding possessed by an individual. Gavelek and Raphael suggest that the questioning focus on three issues:

1. Is the individual giving clues that personal cognition is being monitored?

2. Is the individual's cognitive performance improved by use of such strategies?
3. Is this behavior exhibited in multiple content areas?

Gavelek and Raphael (1985) suggested that questioning is a very powerful technique for assessing comprehension and is often described as the most frequent instructional activity. Questioning activities that attempt to elicit information relating to student comprehension were the focus of Gavelek and Raphael's paper.

Gavelek and Raphael (1985) described uses of questions within the context of reading comprehension. Within this context, there are two primary functions of questions: to promote student comprehension of text, and; to assess student understanding of the text. Furthermore, it is important to make a distinction between student-generated and other-generated (e.g. created by teachers or texts) questions when making judgements about student comprehension. That is, complex student-generated questions, requiring rigorous attention to details within the text are to be considered more metacognitively significant than other-generated questions, requiring simple answers drawn directly from the text.

Gavelek and Raphael suggested both that: students may be trained to use questions as a means to encourage and externalize metacognitive activity, and; the ability to ask questions is one of the "primary means by which individuals are able to foster their own comprehension and as such represents a powerful metacognitive activity" (Postman & Weingartner, 1969, p.114). Furthermore, Postman and Weingartner suggest: "Once you have learned how to ask questions, relevant and appropriate and substantial questions, you have learned how to learn and no one can keep you from learning whatever you want or need to know" (1969, p.23).

Though it is conceptually possible to separate information from context, Gavelek and Raphael (1985) suggested that knowledge is psychologically inseparable from context, and that learning the skills required to use questioning as a means to develop personal comprehension is accomplished through socially mediated channels.

Once the pre-instructional state of a learner's content understanding is known, a number of steps may be taken by the instructor to further encourage the appropriate use of questioning and other metacognitive strategies in instructional activities (Gavelek & Raphael, 1985; Gourgey, 1998). However, research seems to imply that self-reporting of conceptual understanding is unreliable, and that practical experiences and associative activities (such as questioning) may be required to actually induce the students to use personal strategies in the classroom (Gavelek & Raphael, 1985; Pressley, et al., 1998). For example, Pressley, et al. (1998) suggested that high achieving students may overestimate personal metacognitive strategy use, and lower achieving students may conversely underestimate personal strategy use. However, scholastic achievement is not always directly correlated with metacognitive ability. Some students may score highly without much effort because they already possess expert understanding, while some students may fail despite exerting massive amounts of effort toward understanding (Sternberg, 1998). Since students of varying abilities tend to self-report strategy use differently, detecting metacognitive activity should be accomplished through both active and observational means (Pressley, et al., 1998). That is, though Gavelek and Raphael suggested that questioning is an effective method for developing insight about student understanding, other researchers suggest that questioning alone is unreliable because self-reporting of personal understanding is unreliable (e.g. Shepard & Kanevsky, 1999).

Gathering evidence about conceptual understanding may need to incorporate information gained from multiple sources (e.g. Everson & Tobias, 1998; Lin, Moore & Zabrocky, 2000).

Guided Reflective Questioning

Blank (2000) explored using the Science Curriculum Improvement Study learning cycle (SCIS) against the Metacognitive Learning Cycle (MLC) with six classes of grade 7-8 students learning about ecology. The SCIS learning cycle gives students opportunities to reveal their prior ideas about science in two ways. First, students make predictions about the content before they explore further. Second, students engage in hypothesis generation to provide explanations for events not adequately understood. The model consists of three consecutive phases: exploration, introduction to concepts and application of concepts (Lawson, 1995).

The MLC is based upon Barman's (1997) revised learning cycle, but also requires students to reveal and reflect upon the condition or status of their current science conceptions. The reflection takes the form of the conceptual change model, wherein students are asked to decide whether their current idea is intelligible, plausible and fruitful. The MLC is different from the SCIS in that it allows students an opportunity to directly reflect upon their conception at each of the four stages.

In Blank's study, 46 students participated in a three-month unit on ecology. Of the six classes, two classes were chosen for closer examination. Both study group classes studied the same ecological content, but one class (n=22) was taught using the SCIS model, and the other (n=24) was taught using the MLC model. Students in the MLC treatment kept written journals of interactions with their own ecology conceptions, monitoring and tracking how the personal conceptions held up under scrutiny. All students engaged in thinking-aloud style

discussions and small-group discussions, which were audiotaped. To provide the opportunity for more detailed understanding, the researchers selected six students from each class ($n=12$) in the study group for closer observation; two high achieving students, two average achieving students and two low achieving students. The twelve students in the smaller examination groups were interviewed twice; once before the unit began, and again immediately after the unit ended.

Blank's (2000) results indicated that the SCIS and MLC groups performed similarly on a post-test. Furthermore, on two time-delayed examinations – one of them was two months after the end of the unit, and another was four months after the end of the unit - the MLC group mean score (83.9) was still significantly higher than the SCIS group's score (74.8). Blank concluded that the members of the MLC group had substantially and significantly altered their initial personal conceptions. Furthermore, the conceptual change due to the MLC treatment took place in a way that was more permanent than the changes due to the SCIS treatment.

Moreover, the quality and depth of discussion in the MLC group was considerably more engaging and thoughtful than evidenced by the SCIS group. Blank suggested that the depth and quality of the discussions resulted from students requesting justification for every assertion made by the instructor, as well as from other students in the class. The additional rigor exhibited by the students made the instructor feel threatened at times. She even reported feeling the students were outside her control because they questioned nearly everything she said.

In this study, Blank indicated that the MLC approach was quite effective for students learning about ecology. The students using the MLC approach tended to make a greater

number of fundamental and beneficial improvements to their personal conceptions and also retained these improvements over a longer time period. These results gave some support for the notion that instructors should maintain an understanding of student conceptions throughout an instructional process. Such information may allow an instructor to know which conceptions are shared and well understood by the students, and which concepts require more instructional support to be more fully understood by the students. Blank urged more research before making general conclusions about the strength of the method in areas different from those she studied.

Rational Reasons for Metacognition

Several researchers claim the most important critical thinking skill is the ability to maintain a fundamental understanding of personal theories and strategies. Such fundamental understanding is the result of a learner's ability to monitor and systematically consolidate personal knowledge (Schraw & Moshman, 1995). In these terms, merely using a strategy is less important than knowing when to use a strategy appropriately (Mason, 1994). There are several influences that guide the production of personal critical thinking conceptions. Among these influences are constructions based upon cultural mores, interactions between peers and individual abilities.

Cultural development of metacognitive theories is accomplished by social mediation of individual understandings. Some of the methods that help to encourage social mediation are group projects, class discussions and other shared, active presentations of personal understanding. Once a large group of individuals has come to consensus on the nature of cognition, the resulting cultural consensus may be transmitted through normal cultural means. For example, cultural transmission may occur through further peer interaction, or in

some cases, through formal instruction (Palincsar & Brown, 1984; Schraw & Moshman, 1995). In the case of cultural transmission, theories created by a large group of learners often have more influence and support than theories created by a single person in isolation. Thus, an individual is more likely to adopt a conception that has group support than to retain a personal conception that does not agree with the cultural conception.

Peer interaction allows for a pair or small group of learners to openly share and compare theories about a process. One potential outcome of this peer interaction is that each pair of students will identify discrepancies between their personal theories. After discrepancies are identified, the pair of students may work through a process to reconcile the differences, or perhaps develop a mutually acceptable theory. The newly developed (shared) theory will have some robustness, due to the collaborative nature of its development. However, the new theory may still have many factual flaws, and may not resist the power of a socially-developed (larger group) conception (Pontecorvo, 1993).

Individually created theories about science topics are the most numerous and highly varied of all science conceptions (Hewson, 1981, 1984; Posner, et al., 1982). These science theories arise from both formal and informal instruction or experiences with science content (Flavell, Miller & Miller, 1993). Over time, individuals have developing and revised their personal theories, and thus, the theories have a fairly high level of resistance to change (Dweck, Chiu & Hong, 1995). Because these personally-created theories are produced by individuals, the manner in which they are created is often not based on scientific experimentation, rather on generalizations and suppositions (Hewson, 1981; Rogan, 1988). As such, personally created theories are also highly prone to errors (Posner, et al., 1982).

Experimental variable control and experimental design are two areas where novice science students may possess incorrect or incomplete conceptions, and thus may have difficulty understanding how to control variables or adequately design experiments (National Academy of Sciences, 1995). Variable control is perhaps one of the most important issues in science understanding and the development of experiments.

By controlling experiments and the values of variables, the effect of each variable can be determined systematically. That is, if a scientist wished to determine how light affects plant color, she might perform an experiment using plant seedlings that were otherwise identical. In her experiment, she might cover one seedling for two weeks so it received no light, while allowing another seedling to get normal amounts of light for the same period. As long as she treated the two plants equally in all other respects (fertilizer, water, etc.), the scientist could empirically compare the plants with respect to their color at the end of the two week period and attribute the differences she detected to the amount of light each seedling received. A poorly designed experiment might involve covering one seedling for two weeks and giving it plant nutrients, but allowing the uncovered seedling to get normal amounts of light for two weeks, but no water. At the end of the experiment, the scientist could not reliably determine where the difference in plant growth has come from, since more than one variable was changed during the experiment.

Variable control is such an important skill for students to develop that the *Benchmarks for Science Literacy* (American Association for the Advancement of Science, 1993) suggested that students should know how to control variables correctly by the end of the fifth grade. However, the National Science Education Standards acknowledge that

“students will have trouble with variables and controlled experiments” (National Academy of Sciences, 1995).

Until individual students learn to design experiments by limiting the number of variables changed between treatments, science understanding may be very difficult to attain (Lin & Lehman, 1999). Previous research has suggested several factors contribute to student understanding of variable control. Among these are learner development (Inhelder & Piaget, 1958), complexity of task demands and degree of student motivation (Ross, 1988).

Other factors preventing students from properly applying variable control are instructional by nature. Some of these factors include: focusing on memorizing procedures without giving information about how to apply them (Ross, 1988); failing to help students recognize bad research designs (Sneider, Kurlich, Pulow & Freidman, 1984); and teaching procedures without context (Schauble, Glaser, Duschl, Schulze & John, 1994). In each of these cases, students are expected to discriminate the good and the bad designs using passive methods and specifically not by personally experiencing the flaws in the experiment designs.

Lin and Lehman (1999) investigated the use of metacognitive supports designed to help students learn about the importance of controlling variables in experiments. Moreover, they wanted to help use their understanding of variable control to solve novel problems. That is, they wanted to see if metacognitive supports could enable both near- and far-transfer of variable control knowledge.

Another aim of Lin and Lehman’s (1999) study was to determine which type of instructional prompts were most effective encouraging students to make their learning processes explicit. Three different types of prompts were explored; reason justification, rule based and emotion focused. Reason justification prompts requested the students to give

rational reasons for their actions. Rule based prompts asked students to explain the rules or procedures they followed. Emotion focused prompts asked students to reflect on their feelings toward the activity.

To study the effect of each type of prompt, eighty-eight students were split into four equal sized groups; one group was assigned to a reason-justification group, another group was assigned to a rule-based group, another group was assigned to an emotion-focused group, and a group was assigned to the control group, which received no explicit prompts. Four versions of a computer simulation of a biology concept were created; each version customized for one of the groups. For example, the simulation that was customized to prompt emotional responses was used by the emotion-focused group. The control group's simulation did not use any student thinking prompts.

Lin and Lehman's (1999) study lasted seven weeks. Four weeks prior to the simulation exposure, all participants completed a paper and pencil pretest. Students were assigned to groups and advised about the significance of the group to which they were assigned. That is, each group of students was told which kind of prompts they would eventually see in the simulation. After completing their simulation exposure and receiving the appropriate prompting, the participants completed a post-test. The post-test included components that tested for near transfer (solving problems with similar context to learned context) as well as far transfer (solving problems with different context than learned).

Quantitatively, the four groups appeared similar on all pre-test measures. On post-test measures, students in the reason justification group scored slightly higher on near transfer tasks, though the difference was not significant. On the far transfer task, however, the reason justification group scored significantly higher than all other groups.

Qualitatively, the students in the reason justification group scored higher on measures indicating understanding of processes and procedures. The rule based group scored higher than all other groups on questions that required task-level understanding, and the emotion-focused group scored higher than all other groups when asked questions of an emotional nature.

The results of Lin and Lehman's (1999) study suggest that students should provide rationales or justifications for their actions when completing variable control tasks. Moreover, the results seem to have significance for far-transfer tasks. That is, reflection may result in a greater level of conceptual understanding than the other factors studied. In terms of metacognition, expecting students to provide reasons for their actions simultaneously makes each student aware of her current conception, as well as providing a personal rationale for selecting the chosen conception. Reflection may help place students in control of their own learning and help them organize their solution strategies.

Metacognitive Knowledge vs. Metacognitive Control

A primary difference between metacognitive knowledge and metacognitive control lies in the fundamental difference between cognition and knowledge. Whereas cognition may be defined as use of acquired knowledge, knowledge is defined as "facts or ideas acquired by study, investigation, observation or experience." (Websters 9th Ed.). According to Schraw & Moshman (1995), metacognitive knowledge is what one knows about cognition. Metacognitive control is the use of metacognitive knowledge to control, or provide direction for, cognition.

Knowledge is further defined in three significant ways. Declarative knowledge (to extend the metacognitive analogy) is what learners can express about their personal cognitive

abilities (Garner, 1987; Schneider & Pressley, 1989). Procedural knowledge is the ability to strategically plan and sequence the use of multiple strategies to solve problems (Pressley, Borkowski & Schneider, 1987). Conditional knowledge informs the “when and why” decision about which strategies a learner should activate. Generally, students with effective metacognitive skills more accurately self-report their level of knowledge, and are able to more effectively monitor their learning and develop better plans for future learning (Everson & Tobias, 1998).

Everson & Tobias (1998) investigated the ability of students to monitor their own cognition. To accomplish this, given concerns about the age of their subjects (college-aged students) and the negative association given to self-reporting with this age group, Everson and Tobias introduced a method called KMA, that stands for Knowledge Monitoring Ability. The KMA utilizes a simple framework for judging effective reading comprehension monitoring skills.

The KMA consisted of two parts. In the first part, students were given word lists containing 33 words. Students were asked to mark the words for which they thought they knew the definition. In the second part, students were given a vocabulary test containing the same 33 words and were asked to provide definitions for the 33 words. After the second test, the students’ tests were scored.

The KMA results for each word were thus assigned scores. the first value of each pair was based on the student’s prediction about the meaning (+ for predicting knowing, - for predicting not knowing), the second value of each pair was based on the student’s definition (+ for correct definition, - for incorrect definition). In this manner, the KMA attributes a score of:

(++) indicated student claimed to know a word, and provided an accurate definition for the word on the vocabulary test

(+-) indicated that the student believed he knew a word, but provided an inaccurate definition

(-+) showed that the student did not know the word, but provided an accurate definition for the word, and

(--) indicated that the student claimed to know the word, and provided an inaccurate definition.

Everson and Tobias thus treated (++) and (--) scores as accurate metacognitive judgements, and the (+-) and (-+) scores were treated as inaccurate judgements. These judgements were then compared with other measures to evaluate if the KMA could be used as an independent self-monitoring tool. The other measures were: Cumulative GPA: GPA in English courses; GPA in humanities courses; GPA in science courses, and; GPA in social science courses.

In the first of two studies, 84 participants completed the KMA activities. Comparisons were built between students completing a nursing program (N=33) and students enrolled in a freshman orientation course (N=51). In this iteration of the study, 38 words were defined either explicitly or implicitly. Results of the first study indicated that knowledge monitoring scores and GPA in English had the highest correlations. The significant correlation showed that students with higher GPAs in English were more accurate in reporting their personal level of vocabulary knowledge than were students with lower GPAs in English. Generally, this study was performed to set a baseline for the second study.

The second study investigated the KMA's predictive validity. That is, whether the KMA helped to predict how students would perform academically during their first year of university work. Using the same word list protocols as the first study, the KMA was administered to the students. Results indicated that students with higher-than-median GPAs scored higher on the KMA than did students with lower-than-median GPAs. Furthermore, students with higher than median GPAs in English scored higher overall on both applications of the KMA.

Overall, Everson and Tobias found that the KMA was able to measure cognitive monitoring as well as accurately predict performance on the vocabulary assessment while the vocabulary test was totally unable to predict or measure cognitive monitoring. Aside from the significantly better performance on the vocabulary assessment by students with higher GPAs in English, none of the other interactions were significant.

Everson and Tobias (1998) study gives some support to the notion of using multiple, independent methods to detect metacognitive monitoring as well as predict student accomplishment in the field being studied. Everson and Tobias' (1998) study also helped to lend some support to Sternberg's (1998) assertion that metacognition has components which are domain-specific and components which are domain-general. That is, when testing for awareness of vocabulary terms (domain-specific knowledge), English GPA may be more predictive of success or outcome than general GPA (domain-general knowledge).

Interpersonal Differences

Every student who enrolls in school is different, with respect to the number and quality of experiences he has had. Some students have engaged in extensive amounts of formal training in science, while others may have pursued interests in art or music.

Suggesting that there is a “one size fits all” approach to instruction ignores the effects that differences between students can have on their abilities to develop their learning. Several studies investigating personal differences have been completed recently. Some of the areas investigated include differences between students with respect to: level of student expertise (Sternberg, 1996, 1998); student cognitive ability, gifted vs. non-gifted students (Sheppard & Kanevsky, 1999); age differences between groups of students (Lin, Moore and Zabucky, 2000); changes in biological conceptual understanding with respect to student epistemology (Martin, Mintzes & Clavijo, 2000), and; classroom differences due to level of instructor metacognitions (Artzt & Armour-Thomas, 1998).

Expertise

Sternberg (1998) began his report by suggesting that abilities reflect developing expertise rather than innate “potential.” Furthermore, Sternberg maintained that expertise is not an end state, but rather a lengthy process of continual development. In light of these assumptions, Sternberg suggested that expertise is produced through some combination of genetic disposition and personal experience. Furthermore, Sternberg suggested that IQ and other school-related achievement tests are not particularly predictive of success in a job or career. That is, scoring highly on an IQ test may indicate a general mastery of the content contained on the test, but is not necessarily helpful in the work environment. Why? Sternberg suggested that perhaps the reason is that different levels and types of expertise are required in the workplace than are required in schools (Sternberg, 1998).

Sternberg (1996) further identified several factors that tended to differentiate experts in any given field from novices. These factors were descriptive of differences in how experts

tended to deal with classifying problems, identifying solution strategies, implementing the strategies and verifying solutions.

Gifted Students in Homogeneous or Heterogenous Classrooms

Sheppard and Kanevsky (1999) reported a study that investigated the differences in how students of varying cognitive abilities activated personal metacognitive strategies. The study compared how gifted students in homogeneous classrooms (i.e. all students are classified as gifted) and gifted students in heterogeneous classrooms (i.e. most of the students in the classroom were non-gifted) reacted to a five-day training session on conceptualizing the inner workings of the mind.

In the homogenous classroom, all of the 13 students were classified gifted. based upon achievement on an intelligence test. In the heterogeneous classroom, only three of the 26 students were classified as gifted. Whenever students in the heterogeneous class were assembled into groups, the gifted students were never placed into the same group.

Students engaged in the study completed a “mind machine” activity, wherein each student tried to develop a machine that explained the inner workings of her mind. After initial individual development of ideas, students were placed in small groups where the ideas could be discussed. Following the small-group interchange, the class as a whole engaged in a comprehensive discussion about the ideas developed in the class. Data were gathered based on differences in student conception about mind processes on the first day and mind process conceptions on the fifth and final day of the training period. Among the different types of data analyzed were mind machine activity sheets and videotapes containing interview responses and observations of classroom behavior.

Results of this preliminary study suggested that all gifted students made gains with regard to changes in their mind concepts. However, in the homogeneous environment, students demonstrated a type of peer mentoring that was not evident in the heterogeneous classroom. Sheppard and Kanevsky (1999) suggested that such a difference may have arisen due to pre-existing differences in the way the students relate to one another and/or due to differences in the classroom atmosphere. That is, perhaps the gifted students were more willing to share ideas openly because they have been encouraged to do so in the past. The study's conclusions suggested that gifted students tended to benefit more when grouped with other gifted students than when grouped with non-gifted students. However, since the study was preliminary in nature, the researchers called for more studies and more in depth examinations of the effects found in Sheppard and Kanevsky (1999).

Age Differences

Lin, Moore and Zabucky (2000) reported a study that compared how students of varying age activated metacognitive strategies when reading narrative or expository texts. 120 students were selected based on age for participation in the study. 60 of the students were 23 to 35 years old and were classified as "younger students." The other 60 students were 61 to 84 years old and were classified as "older students." To more accurately identify the differences between the groups, an instrument called the *Metacomprehension Knowledge Scale* (MCS) was used (Moore, Zabucky & Commander, 1997) to measure participants' metacomprehension abilities.

The MCS has seven components that help to differentiate the mental processes that inform the decision to activate metacognitive strategies. The seven components are regulation, strategy, task, capacity, anxiety, achievement and locus. Regulation is the use of

personal strategies to solve comprehension problems. Strategy was the learner's knowledge about the employment of effective strategies. Task was personal knowledge of basic comprehension processes. Capacity is personal knowledge of comprehension abilities. Anxiety is the stress associated with solving comprehension problems. Achievement is the value participants placed on possessing good sets of comprehension skills. Locus was defined as the perceived control of comprehension skills and abilities.

Results of the study indicated that personal appraisals of cognitive ability were more highly predictive of younger adults' cognition than of older adults' and is better able to predict comprehension on expository texts than narrative texts. Furthermore, anxiety was the best single predictor of comprehension performance for older adults. This result tends to support the notion that as adults become older, their comprehension may become more closely tied to affective measures.

Biological Knowledge and Epistemological Differences

To investigate the role of epistemology on student ability to engage in metacognitive reflection, Martin, et al (2000) asked third year students enrolled in a marine biology course to use concept maps to describe their current understandings regarding marine ecosystems. 74 students participated in the study, which took place over the course of a single semester. Along with concept maps, the researchers engaged the student participants in interviews.

At three to five week intervals, all students were asked to draw a concept map that represented their current understanding of the constitution of a marine ecosystem. With the exception of the first map, all maps could either modify a previous map, or be drawn totally anew. To address the research questions regarding metacognition, the researchers selected two participants. One participant exhibited very highly organized metacognitive and

reflective monitoring on her thinking, whereas the other participant did not demonstrate these facets.

Results of the study indicated that successful learners in natural sciences may be able to more accurately develop, monitor, regulate and control their thinking processes. Furthermore, the researchers reported that simple awareness of personal learning strategies was not sufficient for success. Rather, awareness was the first requisite step toward monitoring, regulation and control. In other words, all of the facets were present in the student who was the model of a successful natural science student, while only awareness was present in the student who was not successful. Martin, et al. (2000) suggested that many students lack the basic skills to recognize the limitations and metacognitive aspects of their personal thinking skills. Suggestions for future research include studies that encourage students in large-scale settings to develop the skills to learn how to learn.

Differences in Instructor Metacognition

Artzt & Armour-Thomas (1998) developed the Teacher Metacognitive Framework (TMF) to investigate the mental activities of in-service teachers. Using the work of Jackson (1968) as a guide, the researchers developed the TMF to elicit details about teachers thinking prior to teaching a lesson, while engaged in teaching a lesson and after teaching a lesson. The study group consisted of seven beginning teachers and seven experienced teachers of mathematics. The participants were asked to prepare a lesson that would allow the researchers to gain some insight into both classroom practice and thoughts which inform classroom practice. Data were collected in the form of videotaped lessons, audiotapes of interviews and each teacher's written lesson plans.

The researchers identified seven categories of teachers' thinking and classified these categories according to whether they were pre-active, interactive or post-active. The categories were lesson planning (pre-active), monitoring, regulation (interactive), assessing and revising (post-active).

Results of the study indicated that within the 14 participants were three general groups. The researchers called the three groups X, Y and Z. Group X consisted of five members, four experienced teachers and one new teacher, and was characterized by an awareness of student metacognitive abilities and a concern for the fostering of such abilities in their math students. Group Y consisted of four members, all new teachers, and was characterized by an overarching concern with personal teaching practices. Group Z consisted of 5 members, three experienced teachers and two new, and shared traits with both the other two groups of teachers. The researchers identified two sub groups within group Z. Group Z1 shared planning traits with group X, but in all other ways were similar to Group Y. Group Z2 was in most ways similar to group X, but shared knowledge-level beliefs with Group Y.

Artzt and Armour-Thomas' study (1998) identified four weaknesses and areas where the study could have been expanded. First, the study only looked at instructors and did not take into account any information about students in the instructors' classes. Second, the study was based solely on data that was volunteered by the teachers. Third, the number of participants was rather low for the study to have any general applicability. Finally, the study may have benefited from the inclusion of various other types of data, such as questionnaires, surveys or other experimental tasks.

Factors Influencing Metacognitive Strategy Use

Cognitive strategies are primarily used to help augment a learner's current level of comprehension. Metacognitive strategies are thus useful in helping to monitor and direct the use of appropriate cognitive strategies (Flavell, 1979). Dewey's (1916) *Democracy and Education* provides some details about critical / metacognitive / reflective thinking by describing the role of formal education:

Education in schools is an experiment in a developmental laboratory, wherein the subjects are not taught to seek an end or finality in their thinking, but rather to develop an ability to think intelligently about an ever-broadening range of activities (Dewey, 1916).

This quote seems to require a bit of discussion before its message makes sense. Dewey identified the school as an adjunct to society, not an entity abstracted from society. Further, he suggests that school is a place to encourage development of thinking abilities, not simply the location where pre-processed facts are dispensed. Dewey also seems to imply that as children develop into adult thinkers, the role of formal education should change to more accurately challenge the abilities of each student.

Several assumptions about metacognitive strategy use are tied heavily to development (Inhelder and Piaget, 1958; Piaget, 1964). For example, a person operating in the concrete operational phase of development is assumed to hold a more sophisticated set of strategies for solving problems than a person operating at a pre-operational level (Piaget, 1964). However, Kuhn argues that development is not always tied directly to an enhanced set of problem solving strategies (Kuhn, 1999). Instead, students who possess a sophisticated set of cognitive strategies are found to achieve more highly in instructional environments

(Gourgey, 1998). Higher achievement arose from the ability to identify goals, self-monitor progress, self-question the choice of behaviors, and self-assess results. Conversely, students who resist learning metacognitive skills may be afraid to fail, or reveal their current level of intelligence openly (Gourgey, 1998).

Schoenfeld (1987) investigated the effect of using metacognitive skills training to help students learn mathematics. He found in previous studies that novices in mathematics often selected strategies and used them without properly assessing the strategies' worthiness and robustness. In contrast to the novices, experts spent more time identifying an appropriate strategy to use, and furthermore, continuously evaluated the value of the selected strategy to provide a correct solution. If an expert sees that a given strategy is not working out, she will notice this shortcoming much faster and will abandon its use much sooner than a novice will. Schoenfeld (1987) reported three methods for teaching students how to become more metacognitively aware and to monitor personal cognitive abilities. They are:

1. explicitly make students aware of metacognitive strategies, and instruct students in using them;
2. watch other peer students working on similar problems; and
3. use think-aloud procedures to externalize thought processes.

Gourgey's (1998) study investigated the effectiveness of teaching students to think metacognitively. The study analyzed students in two treatment groups. One of the groups received direct instruction on how to use metacognitive strategies and the other group viewed the problem-solving process of peers on a videotape and was asked to critique the group's activities in solving the proposed math problem.

In the direct instruction approach, students were taught to systematically analyze various math problems and identify any simpler relationships between elements of the problem. In addition, a generally effective model for applying these problem-solving strategies was presented to the students, which included a sampling of procedures for monitoring and evaluating each strategy. The instructor served as a catalyst for encouraging students to externalize their thinking processes and monitor strategies. The direct instruction approach was found to be effective in increasing students' problem solving ability based on post-test performance. The direct instruction approach also increased student attention on underlying components of the model, instead of focusing on superficial features of the problem itself.

The second approach involved having students watch peers (students of the same age) working toward solution of similar math problems. The students in this application were all mathematics majors and were resistant to changing their personal ideas about math before watching the videotape. The videotape showed students failing to reach appropriate solutions, and the viewers suggested the reason was based on a lack of self-monitoring and self-reporting of progress. After watching the videotape, the student subjects were willing to actively monitor their own thinking and make appropriate changes to their personal theories of mathematics.

Thinking-aloud strategies placed students into active learning groups. These groups consisted of pairs of students; one student was the presenter and the other student was the listener. By turns, the presenter asks a question and works through the solution out loud. The listener then asks questions that might assist the person thinking through the solution. The

questions are supposed to be similar to the type that instructors would typically ask students engaged in the same type of thought process.

Gourgey (1998) claimed that all of these strategies were effective precisely because they placed students into situations where they were in control of their personal thinking strategies and skills. Each of these methods encouraged students to self-monitor, to make clearer distinctions about the quality of particular strategies and to think about how particular strategies might be more or less useful to solving problems than others.

Cultural and Contextual Influences

Individual cognition may also be influenced by cultural and contextual influences on cognition. The roles of cultural and contextual influences on cognitive and metacognitive abilities also have been a subject of some debate. For the purposes of this discussion, context is defined as the environment of thinking and learning. Context may also include the way certain types of content are taught. For example, science instruction is assumed to take place in a very different context than learning in non-science domains.

Context is also believed to tie in almost directly with cognitive strategy building. Gavelek & Raphael (1985) assert that *how* we think is related to *what* we are thinking about and the *context* of action (emphasis mine). These claims require a certain level of belief in community sense-building before they can be accepted. To make a slight venture into epistemology, many theorists believe that social construction of reality is one of the most powerful influences on an individual's conception building activities. As was discussed above, social influences on conception building tend to be the strongest influence described (Palincsar & Brown, 1984; Schraw & Moshman, 1995). In brief, each context may have its

own set of beliefs, all dependent on the strength of the social influences used to develop them.

Despite this assertion, many researchers maintain that metacognitive thinking skills and cognitive strategy selection is a domain general activity. That is, metacognition is a skill that can be learned once and applied in all areas with equal success. Thus, metacognition is the goal and the beliefs are only tangential to the discussion. In essence, these two groups agree that metacognition is powerful as a thinking and problem solving strategy. However, they are at odds with regard to its applicability or generalizability.

Deciding which of these groups is “right” may be very difficult, given the basis of metacognition in definition. That is, by definition, metacognition occurs on the personal level, but is influenced by many factors. The applicability of a given individual’s metacognitive thinking strategies to various other fields may or may not indicate anything about that individual’s strategy viability. As noted previously, using metacognitive methods for strategy development is better understood in some fields than in others (Kuhn, 1999). Using metacognitive methods for strategy development is usually not tied with cognitive development (Schraw and Moshman, 1995).

To attempt to address this disparity in metacognitive understanding, Wolters and Pintrich (1998) investigated several issues related to contextual and social pressures with respect to use of metacognitive thinking skills and strategies. Within their study, the issue of context pertains only to content learned in school. Their study involved 545 students in seventh and eighth grades. These students completed a self-reporting questionnaire that asked each student to rate two different facets of problem solving: motivation to solve problems and cognition. Motivational beliefs consisted of perceived task value (the level of importance

the individual placed on the solving of each problem), self-efficacy with regard to individual ability to solve the problems and test anxiety. Cognitive factors included cognitive strategy use and self-regulatory (metacognitive) strategy use. Further, the students were assigned a scale-based score that measured performance during the term the study took place. The thirteen point scale assigned a score of twelve to students with an A+ average and a zero for students with an F average.

The students completed the questionnaires at approximately the midpoint of an academic semester, during math and English classes. Student responses to the questions helped Wolters and Pintrich (1998) to assess student motivational and cognitive abilities in subjects of mathematics, English and social studies.

Results indicated that both males and females attributed significantly higher task value to problems in the mathematics domain than to problems in the domains of English and social studies. In terms of self-efficacy, students gave themselves higher scores in English than in mathematics and social studies. Post hoc tests indicated that males had similar levels of self-efficacy in all three subjects, while females had significantly higher self-efficacy in English than in mathematics and social studies. Test anxiety was found to be uniformly highest for social studies. In the area of cognitive strategy use, post hoc analysis revealed that students used more cognitive strategies in social studies than English or math. Furthermore, the students used more cognitive strategies in English than math. There were no significant effects related to self-regulation. Finally, classroom performance measures showed a significantly higher median score for females than males.

These results seem to indicate that students in seventh and eighth grade tend to view school subjects approximately the same way. That is, there were no significantly different

rankings of school subjects, with respect to gender, within the constraints of the study. For example, males and females attributed higher task value to mathematics (solving mathematics problems is more important than solving problems in English or social studies), attributed higher self-efficacy to English (problems in English were easier to address than mathematics or social studies), and indicated social studies required more cognitive strategy use than English or mathematics. The significant effects appeared to pertain to the manner which the remaining two topics were ranked. Even so, Pintrich and Wolters' results showed that one gender group either had no significant differences between the remaining two school topics, or ranked one gender group slightly higher than the other. This study seems to indicate that aside from overall performance in school (which showed that females had significantly higher grades than males), males and females in this age group valued these three school subjects essentially the same way.

One concern with studies that have been performed on metacognition and schoolchildren is that the student participants were nearly homogenous. That is, there are only small, or slightly significant effects attributed between males and females. Unfortunately, there are relatively few studies of the style described by Wolters and Pintrich (1998) that investigate these types of subject-matter/gender interaction effects in high school or university students studying various topics.

General Metacognition Conclusion

The pursuit of knowledge and understanding has probably been a trait of humans since the species appeared. Over the course of time, theories have been developed about how to develop understanding or come closer to understanding why and how things happen. The theories differed widely in terms of the nature of knowledge and reality. Plato believed that

humans were born with an innate understanding of reality, and that the role of learning was one of extracting reality from the deep recesses of the mind. Locke and the Empiricists appeared much later and believed just the opposite. That is, the human mind was an empty cabinet that was filled with experiences. Thus, reflection was only possible after a sufficiently large number of experiences had been accumulated.

Metacognition is not a theory that explains the nature of reality. Instead, metacognition is a set of mental processes that have been studied closely for the past thirty years. Though the term metacognition was proposed by Flavell in the early 1970s, the educational works of Dewey, the developmental ideas of Piaget and Vygotsky's social mediation theories also seemed to provide important context through which Flavell's work could gain broader acceptance. As a mental process, metacognition has a very deep historical and theoretical basis.

Flavell's (1976) definition of metacognition: "Metacognition refers to one's knowledge concerning one's own cognitive processes and products or anything related to them" (p.232) has been widely studied and augmented over the past twenty-five years. Initially, Flavell suggested that two components of thinking and cognitive organization comprised metacognition. The two components were called metamemory and metacomprehension. Metacomprehension is the set of mental processes that lead to the development of an effective set of cognitive strategies. Metamemory is the mental process that helps to identify which mental processes are appropriate in a given situation. In concert, metamemory and metacomprehension provide the decision-making processes as well as the strategies that help to meet cognitive demands at any given moment.

Over the past 25 years, the term metacognition and the processes that are therein described have found numerous areas of application. Primarily, research about metacognition has been pursued in the domain of reading, most often focusing on the learning strategies exhibited by young children (e.g. Hartman, 1994; Palincsar & Brown, 1984, 1989). Lately, researchers have begun to investigate the instructional value of metacognition in other domains and with other age ranges of learners. This review has sought to provide a general overview of both the foundations of the theories that explain metacognition, as well as introducing the potential to help learners in many different domains to be more successful in developing deep understandings of the domain.

The studies cited covered a broad range of the work that has been done to better explain metacognition and its instructional applications. Gavelek and Raphael (1985) and Blank (2000) explored using metacognitive strategies to identify the initial state of learners in classrooms. Building on that awareness, the role of instructors changes to finding activities and experiences that can better address areas where learners possess little or incomplete knowledge.

Much like Dewey's (1916) ideas regarding the role of schools within society and the effect of schools on students' development, Kuhn suggested that schools should help prepare students for life after school. Instead of filling learners' heads with disjointed pieces of information, Kuhn (1999) suggested that schools should teach students how to learn as independent people, and within a curriculum that acknowledges the developmental nature of learners' thinking skills. Schoenfeld (1987) advocated teaching learners how to think metacognitively. With the metacognitive skills, learners are thus prepared for learning how to control their learning, as suggested by Postman and Weingartner (1969).

Schraw & Moshman (1995) and Lin & Lehman (1999) described how learners could use metacognitive strategies to improve or augment their personal conceptions. Using conceptual change methods (Posner, et al., 1982) students were able to identify the shortcomings in their personal theories and to either move toward accepting a better conception or adding significant details to their conceptions to bring them into line with more widely accepted theories.

Everson & Tobias (1998) described a study that seemed to indicate how instructors may use some measures of metacognition to identify student abilities as well as predicting potential in English. Though outwardly similar to the study described by Gavelek and Raphael (1985), Everson & Tobias (1998) accentuated the predictive powers of their metacognitive measure called KMA on the performance of students in English courses.

To answer the question of cultural or contextual influences of metacognition, Wolters and Pintrich (1998) reported a study that involved students' use of metacognition in math, English and social studies. In terms of domains, math may be considered a hard science, social studies might be considered a social science and English may be considered one of the humanities.

Finally, in terms of traditional research methodology, the body of work on interpersonal differences is most straightforward and traditional. Sternberg (1998) described how learners of different levels of expertise develop metacognitive skills and outwardly demonstrate their expertise. Sheppard and Kanevsky (1999) described some differences in how gifted students learned metacognitively within classrooms of gifted or non-gifted peers. Lin, et al., (2000) investigated how university students of traditional university age differ from students of much older age ranges. Martin, et al. (2000) reported how students with

different epistemologies utilized metacognitive strategies in personal learning activities. Artzt and Armour-Thomas (1998) reported on differences found in the way instructors of varying levels of experience behaved metacognitively in the classroom.

Future Directions

Metacognition is a collection of self-controlled learning processes and a number of theories have been proposed to explain it more clearly. Moreover, a number of the theories proposed to describe metacognition have instructional significance. To this point, most of the instructional studies have studied young students, and furthermore those students have mostly been engaging learning to read. However, a notable group of studies in this review have instead looked at students in other disciplines, or within other age groups.

The studies cited have shown that metacognition has shown promise in providing some details about how people of various backgrounds and cognitive abilities monitor and control their learning. However, there appear to be at least three areas that bear closer examination.

First, the body of literature concerning metacognition has not kept pace with some of the more recent research on constructivist learning methodologies and how students react to learning in such classrooms. For example, how do students of differing ages use metacognitive thinking techniques in support of their own learning? Are specific types of metacognitive exercises more appropriate than others for students learning about some topic? Are computer software packages better or worse than live teaching to encourage students to learn to use metacognitive techniques?

Second, very few published studies of metacognition in science have focused on inquiry-based approaches to learning science. Does the effect of students using reflective

thinking techniques to learn about unfamiliar content diminish over time? Can metacognitive techniques be used to help older students learn about science in the same way that metacognition is used to help younger students learn about science? Are all science domains alike with regard to the value and usefulness of metacognitive learning and thinking techniques with students of all ages?

Third, few studies have been published with a metacognition-in-science focus and a population of university-aged or older students. Are university students willing to use metacognitive techniques to learn about content within their major area? What separates an expert level student at the university level from a professor in the same discipline? Do students of university age and older students use similar metacognitive techniques when learning about familiar or unfamiliar content? Can metacognitive techniques be used effectively in a lecture course full of university students?

Conclusion

This paper has provided a summary of the relevant literature pertinent to the development of metacognition theories and their application in instructional contexts, with special attention given to instructional science contexts. The paper identified several areas within science education that have used metacognitive learning and thinking strategies to assist students while learning about science. Among these areas, several studies were identified that analyzed the impact of epistemology, prior content expertise, cognitive ability and student age upon metacognitive use.

This review has also shown that further study in the area of metacognition in science is warranted. For example, how does metacognition affect the use of problem solving strategies in large, lecture-format university science courses? Do older students in large,

lecture-format courses exhibit more or less metacognitive ability than their younger counterparts? Are the research techniques designed to elicit metacognitive strategy details within smaller groups also effective when used with larger groups of students? Can large groups of university-aged students be encouraged to think metacognitively using lecture? What kinds of changes do students who engage in metacognitive, reflective thinking in large lecture format courses produce with regard to their science conceptions? Are the resulting conceptions qualitatively better (more scientifically accurate), or do the students become more expertly proficient at thinking about the concepts in the science course, or is there any effect?

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CHAPTER 3. ARE METACOGNITIVE TEACHING AND LEARNING STRATEGIES EFFECTIVE FOR NOVICE WEATHER FORECASTERS?

A paper to be submitted to the Journal of Research in Science Teaching

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Abstract

This paper reports an exploratory case study of eleven students' use of metacognitive processes in a technology-enhanced introductory meteorology course. The purpose of the case study was to investigate the effectiveness of reflective thinking activities for students enrolled in a large introductory science course. The case study group was enrolled in an introductory meteorology course for non-majors. All students in the class used technological and other enhancements that were designed in part to facilitate students' use of effective metacognitive processing. The study analyzed how novices engaging in metacognitive activities monitored and changed personal conceptions about weather processes and how they used those conceptions to write forecasts. In addition to the course activities, the case study group was interviewed to elicit details about their personal weather forecasting strategies. Among the eleven students in the case study group, several different metacognitive approaches to forecasting were employed. Several students used their metacognitive skills to make changes to their forecasting approaches during the study. The journaling activities, interviews and other metacognitive thinking prompts probably contributed to improvements of metacognitive processes. The report ends with some

suggestions for further research and practice in the area of metacognition with college-aged students learning about science.

Introduction

Metacognition has become a topic of intensive study in the past several years. While the concept of metacognition was described in the early 1970s, early applications of the concept focused on younger children. Moreover, early studies, and a large percentage of the subsequent literature concerns young children learning to read (e.g. Hartman, 1994; Palincsar & Brown, 1984, 1989), or learning to utilize other learning techniques to improve comprehension and understanding, such as questioning and reciprocal teaching (Davey & McBride, 1986). In the past fifteen years, a number of studies have been published that investigate metacognition in other areas, among them are learning in science (e.g. White and Frederiksen, 1998), mathematics learning (e.g. Bransford, Sherwood, Vye & Rieser, 1986) and older students' learning styles (e.g. Aldridge, 1989; Long and Long, 1987).

The purpose of this paper is to report the results of a case study that investigated the use of techniques to encourage metacognition in a large, lecture format science course for university undergraduates. Participants were enrolled in a meteorology course designed primarily for non-meteorology majors. A major, semester-long assignment was writing daily weather forecasts using an online weather forecasting tool. The online tool allowed students to predict the weather for the following day, as well as to review previously graded forecasts. Prior research with this course indicated many students did not use effective metacognitive strategies (Yarger, Gallus, Taber, Boysen & Castleberry, 2000). In the present study, qualitative research methodology was used to investigate the impact of these techniques on university student use of metacognitive strategies.

Metacognition

Metacognition is a set of mental processes that have been described by multiple theories (Flavell, 1971, 1976, 1979). Flavell defined metacognition as encompassing knowledge about cognition and its foundations, a conscious awareness of when thinking or intellectual activities are taking place, a goal toward which some specific cognitive activity is leading the thinker and actions that refer to the strategies employed to achieve the goals (Flavell, 1979). Flavell further defined two constructs that appear to be subordinate components of metacognition itself: metacomprehension and metamemory.

Metacomprehension is the process of developing strategies to maximize comprehension and metamemory is the ability to recall strategies when they are necessary. Metamemory is the process of assessing a situation and activating the most suitable strategy for solving a problem, but also includes the ability to realize that there may not be an appropriate solution strategy available.

By accentuating the metaconceptual ability of learners, it is assumed that these learners will critically view their own theories as well as those of others (Blank, 2000). That is, once the learner is able to both: identify flaws in personal theories, and; acknowledge that more appropriate theories are available, the door may be open to conceptual change (Mason, 1994). When students begin to use their metamemory abilities, they can learn to ask questions whose answers will fill some of the existing gaps in comprehension (Gavelek & Raphael, 1985; Sternberg, 1998). In other words, metacomprehension represents a learner's composite group of strategies and metamemory represents the learner's ability to discern and enact appropriate strategies in appropriate situations.

Developmental Concerns

Schraw & Moshman (1995) described how various types of metacognitive theories are constructed and how such theories are useful for individuals, specifically identifying three sources of metacognitive theories; cultural influences, personal construction and peer interaction. Cultural influences are experiences transmitted via informal activities and formal education (Palinscar & Brown, 1989). The rationale supporting individual theory construction suggests that much of what people know about personal cognition develops outside the realm of formal and informal instruction (Flavell, Miller & Miller, 1993). Peer interaction is an influence arising from the resolution of group dissent by means of collective reasoning (Schraw & Moshman, 1995).

Kuhn (1999) has argued that one aim of public education is to develop individuals that are fully able to participate in a democratic society. To meet that goal, students must be able – at the end of their school careers – to behave as “careful, rigorous thinkers” (Kuhn, 1999, p. 16). Kuhn suggested this goal was often not met, because educators view thinking, unlike mathematics or reading, as an operation separated from clean, clear, age-related patterns. Kuhn also suggested that a debate over the definition of critical thinking stands in the way of preparing instructional activities to foster it. That is, some traditional theorists view critical thinking as a set of discreet mental competencies that are contained within individuals’ heads. Other theorists see critical thinking as an intellectual skill practiced in the company of peers (Rogoff, 1998).

Both Schraw and Moshman (1995) and Kuhn (1999) suggested that students can learn to use critical or metacognitive thinking skills. However, neither study investigated teaching such skills to students in classrooms filled with University-aged students. If Kuhn (1999) is

correct, University-aged students may be receptive to using such thinking skills while learning unfamiliar content.

Epistemology and Changes in Understanding

Several studies that investigated personal differences with respect to metacognition have been reported recently. One area that is of particular interest to the present study is the relationship between student epistemological beliefs and changes to their science understanding. To investigate the role of epistemology on student ability to engage in metacognitive reflection, Martin, Mintzes and Clavijo (2000) asked third year students enrolled in a marine biology course to draw concept maps describing their current understandings of marine ecosystems. The maps were evaluated based on the following criteria displayed in the concept maps: concepts; relationships; hierarchies; branching; crosslinks, and; interconnectedness. Martin et al. (2000) argued that the presence or description of more complex relationships among the items on the ecosystem map reflected a more robust understanding of the ecosystem's relationships. In contrast, a map that only showed a rudimentary set of life forms and their relationships was assumed to show a weak understanding of the marine ecosystems described.

Martin et al. (2000) indicated that successful learners in natural sciences may be able to more accurately develop, monitor, regulate and control their thinking processes. Furthermore, the researchers reported that simple awareness of personal learning strategies was not sufficient for success. Rather, awareness was merely the first step toward monitoring, regulation and control. Despite the findings of Martin et al. (2000), reports of detecting such individual level mental processes within large-scale lecture courses ($n > 100$) are nearly non-existent in the literature.

Metacognition in Science Instruction

Blank (2000) compared the Science Curriculum Improvement Study learning cycle (SCIS) against the Metacognitive Learning Cycle (MLC) with middle school students learning about ecology. The SCIS learning cycle gave students opportunities to reveal their prior ideas about science in a two ways. First, students made predictions about the content before they explore further. Second, students engaged in hypothesis generation to provide explanations for events not adequately understood. The model consisted of three phases: exploration, introduction to concepts and application of concepts (Lawson, 1995).

The MLC is based upon Barman's (1997) revised learning cycle, but also requires students to reveal and reflect upon the condition or status of their current science conceptions. The reflection took the form of the conceptual change model, wherein students were asked to decide whether their current idea is intelligible, plausible and fruitful. The MLC is different from the SCIS in that it gave students opportunities to directly reflect upon their conceptions at several stages.

Students in the MLC treatment kept written journals of interactions with their own ecology conceptions, monitoring and tracking how the personal conceptions held up under scrutiny. The quality and depth of discussion in the MLC group was considerably more engaging and thoughtful than that evidenced by the SCIS group. Blank suggested that the depth and quality resulted due to the students requesting justification for every assertion made by the instructor, or other students in the class.

The students in the Blank (2000) study completed the instructional unit and took an end-of-unit test. Two months and four months after the unit test, the students took follow-up tests about ecology. The results of the study showed that the MLC and SCIS students did not

differ significantly in their scores on the end-of-unit examination. However, the MLC group students performed significantly better than the SCIS group students on both delayed post-test units. Blank argued these results provided evidence that the members of the MLC group had substantially and significantly altered their initial personal conceptions of ecological processes. Furthermore, the conceptual change due to the MLC treatment took place in a way that was more permanent than the changes due to the SCIS treatment. That is, students in the MLC group maintained a more scientifically accurate conception - of the ecological processes studied – over long term. This result indicated that students in the MLC group have undergone accommodation, rather than assimilation, of the concepts. Though Blank's study was completed with student in secondary school, the reflective journaling methods may have some usefulness for any students doing reflective or metacognitive work.

Metacognition and a Physical Science

White and Frederiksen's (1998) ThinkerTools Inquiry Curriculum was created to help students engage in realistic inquiry of physics concepts and principles and to improve their metacognitive thinking skills. The inquiry curriculum consisted of: 1) a computer software package, also called ThinkerTools, which modeled Newtonian-motion physics concepts and. 2) an inquiry-centered instructional approach incorporated into a set of manuals. Some of the important features of the instruction were scaffolded inquiry, reflective assessment and a recursive cycle of generalized inquiry and reflection. Students in the study were encouraged to use metacognitive thinking and learning skills as they utilized the instructional tools in the ThinkerTools curriculum. By consistently monitoring personal thinking and having multiple opportunities to engage in developing personal skills, the students were eventually able to act as independent researchers, using formalized research methods to guide their inquiries.

In the context of the White and Frederiksen (1998) study, scaffolded inquiry allowed students to simultaneously learn about the science concepts and appropriate methods of inquiry. To accomplish this simultaneous feat, students were placed into scaffolded environments, where students learned about the inquiry process using simulations and other tools.

White and Frederiksen (1998) showed that the reflective-assessment tool was very effective for getting secondary school students to revisit their work and show improvement on inquiry skills. This effect was strongest among the lower achieving students, but the reflective-assessment tool also helped higher achieving students perform better on inquiry measures.

Both Blank (2000) and White and Frederiksen (1998) indicated that different types of metacognitive prompts were effective at encouraging metacognition in secondary-aged students learning about science. Very few studies have looked at the use of similar techniques in the large, lecture-formatted courses offered to students of university age. The present study looked at how students used reflective and metacognitive learning strategies to improve their understanding of meteorology in a large introductory (lecture-based) course. Were the new strategies effective with a large group of heterogeneous learners?

Encouraging Metacognition

Encouraging students to openly share their learning and thinking strategies has been a difficult concept. Some research has been done that use either interviews or written activities to try to gather some evidence of metacognition. Some of the recent research involved interviews and concept maps (Martin et al., 2000), concurrent verbal protocols (Taylor and

Dionne, 2000) and peer tutoring (King, 1998). These studies demonstrated that journaling and interviews can provide useful data sources and assessments of metacognitive processes.

These studies demonstrated that the instructional use of metacognitive learning and thinking strategies can facilitate metacognitive development and increased content learning. All of the studies investigated how students in middle school, secondary school or smaller group university courses monitored and made changes to their conceptions.

In the present study, students in a large university class that incorporated technology enhanced active learning techniques were encouraged to reflectively assess their personal learning and thinking strategies about weather forecasting. This class was selected because the instructor was interested in promoting better metacognitive skills in students. The instructor believed that students did not make the most effective use of the supporting technology because they did not employ appropriate metacognitive strategies. Therefore, the present study was designed to assess the impact of two interventions – reflective journaling and interviews – on eliciting metacognitive strategies.

The purpose of this exploratory case study was to examine if metacognitive techniques designed and tested for younger students and for smaller groups of individuals could be used to encourage metacognition for students enrolled in large university lecture courses. The present exploratory case study sought to answer the following questions about integrating metacognitive prompts into a large, lecture format introductory meteorology course:

1. Do students engaging in metacognitive learning and thinking activities tend to change their weather forecasting strategies?

2. Do students using metacognitive learning strategies adopt accurate weather forecasting strategies?
 - a. Do individuals make improvements to their forecasting strategies and thus increase their forecast scores?
 - b. Do students using metacognitive and reflective learning strategies produce forecasts that are more accurate than their peers'?

Methodology

Context

The case study was conducted in a novice-level meteorology course taught each semester at a major midwestern University. The course fulfilled a general education requirement in science. As such, many of the students enrolled in the course were non-meteorology majors. The professor was very interested in helping students learn using various methods. Several of the course lessons were augmented with instructional simulation activities that students completed prior to lecture, providing the basis for discussion about the simulated topic. Though the course was primarily designed as a lecture, a portion of most lecture periods was given over to discussion in small groups. Often, the small groups convened to answer quiz questions that assessed students' understanding of the lecture content. The focus of the course was to encourage students to learn about the physical processes that control the weather. One goal of the course was for students to develop their skill as weather forecasters.

Several professors taught sections of the course, but all research took place in one section, because of the willingness of its professor to investigate the effect of different learning and teaching strategies on student learning. A previous study about this course was

published by Yarger, Gallus, Taber, Boysen and Castleberry (2000) and described the use of an online weather forecasting tool to help students develop skills as weather forecasters. The online forecasting tool was used in conjunction with ClassNet - as described by van Gorp and Boysen (1997) - to give students an opportunity to test their understanding of weather processes and to give students an opportunity to apply concepts taught in lecture in a reality-based context. Moreover, the professor was willing to incorporate reflective journaling activities into the course framework for purposes of tracking what students were having problems understanding throughout the course. That is, the reflective activities asked all students to not only reflect on their forecasting strategies, but to also provide the instructor with some insight to topics that were difficult to understand.

Overview

The present study took place in a meteorology course with 223 students enrolled. With such a large course, the prospect of studying every student was impossible. However, large courses also typically have many interactive or out-of-class activities. These activities were modified so data regarding student thinking and understanding could be collected. For example, the course was modified to include reflective journaling activities – for any students who desired - and interviews. Interviews were only conducted with the case study group students and helped to develop a richer context for understanding forecasting strategies and any changes made to the forecasting strategies throughout the semester. ClassNet helped to collect some of the data students created while completing forecasts and/or other out-of-class assignments. Techniques were developed to collect data about student forecasting strategies from various points of view. The following sections describe the course, the activities that we studied and how we studied those activities.

Participants

223 students were enrolled in an introductory meteorology course at a major Midwestern university. Table 1 summarizes the makeup of the course with respect to GPA, gender, academic major (science vs. non-science) and reason for enrolling. Data relating to gender, GPA and academic major were used to help purposively select students for the study group.

Table 1. Pre-study characteristics

<u>Gender</u>		<u>Enrollment</u>		<u>Career Plans</u>	
Males	Females	Required	Elective	Science	Non-Science
144	87	81	150	119	107
<u>Academic Classification</u>					
1 st Year		2 nd Year	3 rd Year	4 th Year	5 th Year
86		64	49	23	8
<u>GPA Range</u>					
4.0 – 3.5		3.5 – 3.0	2.9 – 2.5	2.5 – 2.0	< 2.0
24		72	59	52	22

The original intent of the purposive sampling technique was used to produce equal-sized case study groups of two types; high achieving science majors and low-achieving non-science majors. The two science achievement groups were intended to provide contrasting groups with respect to conceptual understanding, strategy selection and final grade. However, due to attrition, the original grouping idea was abandoned and the case study group was completed with interested volunteers. The resulting case study group closely resembled the make up of the course as a whole. The case study group consisted of eleven students. A

summary of the study group's attributes is given in Table 2. The names given are pseudonyms.

Table 2. Summary of demographic information for students in the case study group

<u>Name</u>	<u>Year</u>	<u>Major</u>	<u>Career Goals</u>	<u>GPA Range</u>	<u>Science Interest</u>
Arnold	1 st	Liberal Arts	Science	< 2.0	NO DATA
Beth	1 st	Liberal Arts	Non-Science	2.5 – 3.0	Neutral
Christine	2 nd	Liberal Arts	Non-Science	3.0 – 3.5	Moderate High
Daryl	1 st	Liberal Arts	Science	2.5 – 3.0	Moderate Low
Ed	1 st	Liberal Arts	Science	3.0 – 3.5	Moderate High
Fiona	3 rd	Agriculture	Science	3.5 – 4.0	Moderate High
Greg	1 st	Agriculture	Science	2.5 – 3.0	Neutral High
Harold	5 th	Liberal Arts	Science	NO DATA	NO DATA
Ida	3 rd	Liberal Arts	Non-Science	3.0 – 3.5	High
Jane	1 st	FCS	Non-Science	3.0 – 3.5	Neutral
Kathy	1 st	Liberal Arts	Non-Science	2.0 – 2.5	Neutral

Forecasting Activities

Approximately 60 percent of each student's final score was based on forecast scores. The forecast assignments required students to predict the next-day temperature for 12Z and 18Z, wind speed and direction for 18Z, as well as predicting whether there would be precipitation during the 24 hour period between 12Z on the forecast day and 12Z on the following day. 12Z temperature was chosen, because it usually represents the low

temperature for the day, and 18Z represents noon, where the Sun is at its highest point for the day. Zulu is the radio call sign for the letter Z. Zulu time is used by meteorologists as a standard for reporting time. Zulu time is the same as Greenwich Mean Time, and thus for people in the central US time zone, 12Z is 6 AM local time and 18Z is 12 noon.

Students prepared forecasts using online tools as described by Yarger, et al. (2000). To record their predictions, students completed an on-line forecasting form. The form is shown in Appendix A. After submitting the form, student predictions were scored based on accuracy compared to official values from weather reporting stations in the area. A few days later, the forecast scores would be posted on the online course site, where students were encouraged to track their progress as forecasters. The scoring scheme for each facet of daily forecasts is summarized in Table 3. The rationale for giving a single point for incorrect predictions rewards effort. That is, every forecaster knows that she will get at least one point for every answer given.

Table 3. Forecast scoring summary

Forecast Item	Acceptable Range	Point Values	
		Correct Score	Incorrect Score
Temperature	+/- 5 degrees F	3	1
Temp. Influences	Correct Answer Only	3	1
Precipitation	Correct Answer Only	3	1
Precip. Influences	Many possible answers	3	1
Wind Speed	+ / - 5 knots	3	1
Wind Direction	+/- 45 compass degrees	3	1

Students were encouraged to write as many forecasts as they could, with a maximum of one per day. There were more than 100 days in the semester and thus each student had the potential ability to write over 100 forecasts. Because only the best 25 forecasts from each student contributed toward his or her final score in the course, writing more than 25 total forecasts was a simple, yet effective strategy for earning a high score on the forecast portion of the final grade.

Reflective Activities

The course instructor added two types of reflective activities to aid collection of data for the study; reflective journaling opportunities and interviews. All students enrolled in the course were encouraged to complete the reflective journaling activities for extra credit, but only members of the case study group were interviewed. Both types of reflective activities asked students to personally examine and self-critique the strategies used to write daily weather forecasts.

Journaling

Journaling provided a way for students to describe their forecasting strategy, noting aspects of their personal strategy that were particularly successful or unsuccessful. As a result, the activities were intended to encourage students to try new forecasting techniques and increase their forecasting accuracy. Each journaling activity assumed that each participant (journal writer) had completed a forecast on a specific day, and that she had looked at the score earned by that forecast.

The first journaling activity occurred very early in the semester and requested each student to simply describe the process she used to create a weather forecast. The description asked the students to describe the resources used, such as maps, websites, etc.

The second and third journaling activities asked more detailed questions about each question on the forecast form. For example, the student was asked to describe the maps and resources used to forecast temperature, then cloudiness and finally advection. Moreover, the reflective activities asked the students to specifically review the scores earned on each facet of the forecast and to provide rationales for their scores.

The fourth reflective activity asked students to describe their early- and late-semester strategies for forecasting temperature, precipitation and wind. Next, the activity requested the students to identify, and provide rationales for, any differences (if any) between the early- and late-semester strategies.

Journal entries were collected as data from the online forecasting tool and were coded according to early semester strategy, late semester strategy, student awareness of strategy effectiveness, and rationales for changing strategies, if necessary. Each student produced a set of journal entries. Each set was analyzed in isolation from other students, but each student's entire set was used to gather information about his forecasting strategy. That is, all of the reflective journal entries from a single individual were handled separately from everyone else's, but were grouped together for that individual to provide a richer context for understanding the individual's thought processes.

Interviews

The second type of reflective activity was interviews. Specifically, three different interviews were done over the course of the semester. The first and third interviews had similar aims; to have the student describe the process she used to write a typical daily weather forecast. The first interview took place early in the semester. Participants described the procedure they used to write forecasts at that point in the semester. This interview and the

first set of reflective activities provided a great deal of the information about individuals' early forecasting strategies. The balance of the information about the early strategies came from the third interview, described later.

The second interview sought to capture the process each student used to write a weather forecast and to engage the participants in a discussion about the value of each resource used toward the final decisions made for each of the forecast components. To the accomplish this, each participant was videotaped in the process of creating a typical weather forecast. While students were writing their forecasts, the interviewer asked questions to attempt to elicit the reasoning each student used for selecting particular resources and to get a sense for whether strategies were being used.

The third interview began with students looking back to the beginning of the semester and remembering their initial forecasting strategies. Then the interviewee asked the same questions again about the student's late semester forecasting strategy. After the late semester strategies were described, the interviewer asked the student to rationalize why she changed forecasting strategies, or why the strategies stayed the same.

All interviews were transcribed. Transcripts were coded according to early semester strategy, late semester strategy, student awareness of strategy effectiveness, and rationales for changing strategies, if necessary. Each set of interview transcripts was handled separately for each student, but grouped. That is, all of the interview transcripts from a single individual were handled separately from everyone else's, but were grouped together for that individual to provide a richer context for understanding the individual's thought processes.

Procedures

Over the sixteen weeks in the semester, each student in the course completed several activities. Aside from the interviews, which were only completed by members of the case study group, each student in the course completed the same activities. The course activities are summarized in Table 4.

Table 4. Summary of course activities by week

<u>Week</u>	<u>Activity</u>
1-16	Write daily forecasts (at will)
1	Complete initial class survey
4	Write daily forecast for reflective activity #1 (Appendix C)
5	Interview #1 (that discussed performance on week 4 forecast)
5	First Hour Exam
6	Write daily forecast for reflective activity #2 (Appendix C)
7	Second Hour Exam
7	Interview #2 (video-taped completion of weather forecast)
11	Third Hour Exam
11	Write daily forecast for reflective activity #3 (Appendix C)
13	Write daily forecast for reflective activity #4 (Appendix C)
13	Fourth Hour Exam
14	Interview #3 (that discussed early and late semester forecast strategies)
16	Final Exam

During the first course meeting, all students enrolled in the course completed a brief survey. The survey collected data such as: student classification (first year, second year, etc.): reason for enrolling in the course; academic major; interest in natural science, physical science and meteorology; and a thirty item extract from Schommer's (1990, 1993) epistemology survey. As described earlier, data from this initial survey were used to identify students for the initial case study group.

Soon after analyzing the survey data, potential students were contacted for participation in the case study group. Students that replied were instructed to complete a forecast during one of two days during the fourth week of the course. The forecast assignment was offered to all students as an extra-credit assignment. After receiving their forecast grade for the assigned forecast, case study students were asked to complete reflective activity #1 and also to schedule a time to be interviewed about their forecasting strategies. The first interview asked the students to identify what they did to write their forecast, including a rationale for each of the forecast components.

During week six, all students had the opportunity to write a forecast on a specific day and then to complete the second reflective activity. After completing the forecast, the case study group members were asked to schedule a specific time in the following week to be interviewed for interview #2. The second interview consisted of videotaping each case study group student while she wrote a complete forecast. The student was encouraged to explain, in thinking-aloud fashion, what she was doing at each point during the forecast creation, which resources were used and why the resources were important for the student's forecast strategy. If the student was not providing enough detail, the researcher asked for rationales at several points during the interview.

During week eleven, all students were encouraged to write an extra-credit forecast and complete reflective activity #3. During week thirteen, all students were encouraged to write an extra-credit forecast and complete reflective activity #4. Students in the case study group were further encouraged to schedule interview #3. Interview #3 and reflective activity #4 had the same aim: to encourage students to compare and contrast their early and late semester strategies; to obtain some rationales for early and late semester strategies, and; to determine if there were substantive changes to the strategies used to write forecasts over the course of the semester.

Analysis

The research questions sought to answer whether metacognitive learning and teaching methods helped students monitor personal strategies with respect to weather forecasting and further, if those metacognitive methods helped students make improvements in their weather forecasting strategies. The case study described here was designed to gather information about student metacognition and assess whether students using metacognitive prompts made changes to their forecasting strategies.

However, to provide a richer context for research, some data types were used to answer the question from both qualitative and quantitative points of view. For example, to provide support for the assertion that a student had made a qualitative improvement to his forecasting strategy, data indicating an increase in average forecasting score were also presented. Moreover, to provide some explanation for a rapid increase in forecast score, a few choice quotes from a reflective journaling exercise and/or interviews were presented.

For the purposes of this study, interviews, journaling activities and raw forecasting data were used to triangulate upon evidence of metacognition. That is, findings from each

data type were combined to provide a richer, deeper, more focused description of the individuals' metacognitive activities.

Qualitative Analysis

To answer the research questions, data from the reflective sources – journaling activities and interviews - were collected from each student in the study group. These data were analyzed and coded for evidence of strategy awareness, strategy changes and rationales for strategy change. Coding was done to identify quotes that described early forecasting strategies, late forecasting strategies and whether students were aware of reasons for making changes to their forecasting strategies. To assign students to strategy groups, the following qualitative analysis approach was used.

The qualitative data from each student were initially separated into two parcels: the first parcel consisted of data that pertained to early semester forecasting strategy, and the second parcel consisted of data that pertained to late semester forecasting strategy. The strategies about early semester forecasts were discussed in part within reflective activities #1, #2 and #4 and during the first interview. Late semester strategies were discussed in reflective activities #3 and #4 and during the second interview. Reflective activity #4 was vitally important because it gave a chance to more reliably capture an accurate view of students' early semester strategies as well as helping to capture student strategies about their late semester strategies.

To identify early semester trends, the data contained in the early semester parcel was read very carefully to identify trends within each student's forecasting strategies. Each of the students in the case study gave very thorough descriptions of the types of data they used to create forecasts. Students who used only commercially prepared forecasts for their personal

forecast predictions often used quotes such as “To forecast, I used Weatherbug. I looked at the various things like wind direction, cloud cover, and other facts to figure out what to forecast for the following day.” Weatherbug is a networked forecast viewer, usually tied directly to a commercial weather forecasting vendor, such as a news station. Students who used similarly prepared forecasting tools were considered members of the PreMade group. On the other end of the continuum, some students used data sources that required some interpretation to gather the information necessary for writing an accurate forecast. A representative quote from a student in the Raw Data group was, “I used the ETA temperature model at www.rap.ucar.edu to predict the 12z and 18z temps. By looking at the contours, I estimated what it predicted the temps to be. From the 850 millibar map, there will more than likely be cold air advection in the area causing lower temps.” Students who demonstrated using such raw weather products to create their forecasts were classified as members of the Raw Data group.

This classification scheme also helped to identify students whose forecasting strategies fell somewhere between the extreme ends of the continuum. Students who used strategies based on commercially prepared forecasts, but augmented with raw weather products were classified in the PreMade with Support group. Likewise, students who based their weather forecasts on raw weather products and augmented their forecasts with commercially prepared forecasts were classified as members of the Raw Data with Support group. To obtain a clearer picture, multiple quotes were necessary to classify the strategies used by the students in the intermediate groups. That is, since they used products from both commercial vendors and the raw weather products, the relative number of quotes of each type were important for classification.

After the early semester forecasting strategies were identified and coded, the same process was repeated for the late semester forecasting descriptions. Each student was thus classified based upon early semester strategy and late semester strategy. For students that changed strategies during the study, a similar process was completed to identify statements providing rationales for change.

Quantitative Analysis

To answer research question #2, quantitative data were analyzed. The quantitative data in this case study consisted of forecast scores, epistemology scores from the initial class survey and final grades for each student. Non-parametric statistics were computed to counteract the huge differences in group size between the case study group ($n=11$) and the rest of the course ($n=212$). Mann-Whitney U tests and t-tests with ANCOVA were conducted on the quantitative data produced by the case study group and the rest of the students in the course to determine if significant differences existed.

Results

Qualitative Analysis of Forecasts

The eleven students in the study group exhibited a wide range of initial forecasting strategies, from extremely simplistic to fairly complex. As described above, each student's forecasting strategy fell into one of four categories, based on the reliance the student exhibited on pre-made or commercially produced forecasts. The four groups were identified as PreMade, PreMade with Support, Raw Data with Support and Raw Data. Details about early semester forecasting strategies, late semester forecasting strategies, number of forecasts and final grade percentage are summarized in Table 5.

Table 5 . Summary of case study group participants' strategy selections

<u>Initial Strategy</u>	<u>Name</u>	<u>End Strategy</u>	<u>Forecasts</u>	<u>Final Grade</u>	<u>E.Score</u>
<u>PreMade</u>					
	Beth	PreMade	30	74.8%	102
	Greg	PreMade w/ Support	37	84.3%	98
<u>PreMade w/ Support</u>					
	Arnold	Raw Data	22	49.5%	N/A
	Daryl	PreMade w/ Support	37	86.2%	101
	Ida	Raw Data w/ Support	43	86.1%	103
	Kathy	Raw Data w/ Support	43	75.9%	94
<u>Raw Data w/ Support</u>					
	Christine	Raw Data	64	85.2%	94
	Jane	Raw Data w/ Support	44	77.0%	114
<u>Raw Data</u>					
	Ed	Raw Data	49	83.9%	106
	Fiona	Raw Data	28	76.1%	110
	Harold	Raw Data	89	N/A	N/A

For the purposes of this case study, the strategies used were assumed to increase in complexity from PreMade forecasts to Raw Data forecasts. That is, the PreMade forecast strategy required the least personal involvement in the forecasting process and Raw Data forecasting strategies required the most personal involvement. The next sections describe the

early semester strategies and late semester strategies exhibited by each of the students in the case study group.

Early Forecasts

PreMade Forecast Group

There were two students in the PreMade group: Beth and Greg. Beth was majoring in non-science disciplines and reported no desire to pursue any kind of science-related career. Greg was majoring in a natural science discipline and reported he intended to pursue a career in the natural sciences. Both Beth and Greg were classified as first year university students and reported GPAs in the range 2.00 – 2.99. Students in the PreMade group relied on fully prepared forecasts for their own forecast predictions.

Beth

A typical student in the PreMade group was Beth. Her descriptions of how she forecasted at the beginning of the semester indicated that she relied more than 90% on commercial forecast sources for her forecast predictions:

“To forecast, I used WeatherBug. I looked at the various things like wind direction, cloud cover and other facts to figure out what to forecast for the following day.”

[R1Q1 – Beth]

“I looked at the tomorrow AM and tomorrow forecasts on the weather channel site.”

(Temperature Prediction) [R2Q2 - Beth]

“I looked on the weather bug to see how cloudy it was.” [R2Q3 – Beth]

“I looked at random maps on the weather products page.” (Advection Prediction)

[R2Q4 – Beth]

“Early in the semester I only used the weather channel page to predict forecasts. For the most part, I just guessed about a lot of the questions on the forecasts.” [R4Q1 – Beth]

“At the beginning of the semester, I just looked at the skews on the Unisys. I forget what page that’s from. I’d look to those and saw which direction the winds were pointing and how many barbs were on it to tell how fast it was going and I used the Weather Channel too.” (Winds prediction) [I3 – Beth]

From these quotes, it was clear that Beth was relying almost totally on various commercially prepared forecasts for her predictions. In fact, her comment above about using the weather channel page was very revealing in classifying her into the PreMade group. The only comment about using a raw data source was about Unisys skews and was probably a result of her self-described “random” search for advection information.

Greg

Greg’s responses classified him as a member of the PreMade group. His forecast strategy relied very heavily on commercially prepared forecasts at the beginning of the semester.

“On questions 2 and 6, I make the hypothesis that everything will be the same for tomorrow unless something different happens (wind change, front, high or low) that was different from today. I then go to the weather channel’s maps and see what they have to say about wind, temp. I also try to watch the weather forecast on the news at 5 or 6.” [R2Q2 – Greg]

“For cloudiness, I just look at the radar maps (on the weather channel website) and see if any clouds are projected to move in. I assume the clouds won’t change anything

since we still have snow on the ground and that does a fine job holding down temp.

The radars are important so I can see the clouds – it's that simple." [R2Q3 – Greg]

"I pretty much guessed, or watched the news and saw what they said." (Wind Prediction) [R4Q8 – Greg]

"Early in the semester, it was during winter and usually there wasn't any, so I just looked for something to put in there." (Precipitation prediction) [I3 – Greg]

"Early in the semester, that was definitely something I got off the news."
(Temperature prediction) [I3 – Greg]

As a group, the members of the PreMade forecasts group had the greatest potential for incorporating raw data into their forecasting strategies. That is, the weather forecasting strategies required the least cognitive effort, because they relied almost solely on the professional forecasters at the various commercial weather sites (such as the weather channel or the WeatherBug or the local news) for their own predictions. Just because Beth and Greg used very simple forecasting strategies does not imply that they possessed very little understanding of weather processes. For example, Greg's description of his temperature assumptions was given in class as a rule of thumb for predicting a starting point. Beth's description of her winds prediction, using the Unisys skews also shows a fairly good understanding of what the maps mean, but she used them very rarely, and thus was placed into the PreMade group.

PreMade with Support Group

The PreMade with Support group was characterized by their reliance upon pre-made forecasts, including some raw forecasting tools for special purposes. There were four students in the PreMade with Support group: Arnold, Daryl, Ida and Kathy. Arnold was a

first year meteorology major who reported his GPA was in the range below 2.0. He planned to pursue a science-related career when asked at the beginning of the semester. Daryl was a first year meteorology major who reported that his GPA was in the range of 2.5 – 2.9. He planned to pursue a career in communications and meteorology. Ida was a junior enrolled in a non-science major, with no plans to pursue a career with a science focus. She reported her GPA in the range between 3.0 and 3.5. Kathy was a freshman in a liberal arts discipline who reported her GPA was in the range between 2.0 and 2.5. She planned to pursue a non-science related career and had neither positive nor negative interest in meteorology.

Arnold

Arnold's semester-beginning strategy initially suggested that he was a member of the PreMade group. However, as he produced further descriptions, it became clear that he was more accurately placed in the PreMade with Support group.

"When I first started out at the beginning of the semester I really didn't know anything so I just go straight to the Weather Channel and just take it right off there just to get the grade. As I started learning stuff I... you know as we learned in class about advection through wind in the beginning and we learned about... I started using the graphs on the Iowa State network for the dew point temperatures and the wind direction and wind speed and I look at those and I tried to make ...as well as the current day's temperature." [I3 – Arnold]

"When I start to forecast the weather for the assignment and the current forecast, I first bring up another web page (browser window) and go to the Weather Channel.com and I bring up their maps." [I1 – Arnold]

“I used the previous day’s temperature graph and dew point temperature graph to make predictions for the following day. I also used the satellite graphs to determine whether or not any clouds would possibly effect the following day’s forecast.” [R2Q2 – Arnold]

“To predict advection for the next day, I use the wind direction maps and wind speed maps. The wind direction will tell me whether or not advection will be created due to where the wind is coming from.” [R2Q4 – Arnold]

“I use the weather channel.com doppler graphs to decide whether or not a front is on the way. The doppler radar shows where the fronts are and where they are heading.” [R2Q5 – Arnold]

“Earlier in the semester, I forecasted winds items by looking at the wind speed and directional maps from Iowa State University and making educated guesses as to what it might be like the next day, also I used the weather channel.com to help me make a decision as to which way the wind was [m]ost likely to blow the next day.” [R4Q8 – Arnold]

Arnold’s responses seem to mirror rather closely the definition of PreMade with support. That is, he based a greater portion of his predictions on information gleaned directly from commercial forecasting sites, such as the weather channel.

Daryl

As a meteorology major, who was also taking another forecasting class during the same semester as the study was conducted, Daryl was aware of most of the tools of the trade and how to use them. The following statement from Daryl summarizes why he was initially a member of the PreMade with Support group:

“First off, I always look at the weather channel’s local forecast for the next day to get some kind of idea as to what is going on. Next, I look at the 18z and 6z temperatures from the day before to get a range of values. I look mostly at the surface maps to see which way the wind is blowing and if there is any advection and how severe it is.”

[R2Q2 – Daryl]

“The resources I use to predict cloudiness, are again the weather channel as a resource, and then I will look at the surface map to see which way the wind is blowing and if where it is blowing from has much cloud cover or not. Then I will take a glance at the satellite picture in motion to see which way the clouds are rotating.”

[R2Q3 – Daryl]

When asked why he chose to use the Weather Channel site for his forecasts, Daryl replied:

“They are pretty reliable. People know that if you’re going to go for weather, you go to the Weather Channel. They’re usually within... I mean they’re pretty good about what they forecast. Even my (other meteorology course) teacher uses the weather channel for his weather forecasts, so it’s gonna be a pretty reliable source.” [I1 – Daryl]

Ida

Ida was not a major in a science discipline, but she was willing to try to incorporate some of the raw forecasting tools into her forecasting strategy.

“I usually look at the weather channel’s homepage and look up the forecast for Des Moines for a quick answer. I also look at the meteogram from the University of

Wyoming. But, I also know that if I look at a surface map, it will give me the temperature.” [R2Q2 – Ida]

“When predicting cloudiness, I look at the infrared map. Also, on the surface temp map, it shows the wind and if the circle is filled in, it’s cloudy. The infrared gives the current cloud cover, and if not much changes, it will probably continue to be cloudy.”

[R2Q3 – Ida]

“I watched the weather channel on TV to get their predicted temps for the day. I assumed the hottest part of the day was noon (18z), so I would put their predicted high as my noon temp.” [R4Q2 – Ida]

“For winds, I think I just kind of noticed what was the day before and also looked on the weather channel. But I did not know how to do direction of the wind. I just guessed.” [I3 – Ida]

“[For precipitation] I watched the Weather Channel or online. [For temperature] Same thing, but I also looked at... I did look at surface maps.” [I3 – Ida]

Ida’s strategy was fairly consistent, based on these quotes. That is, she used the weather channel to provide a bulk of information about her forecast predictions, but she would also use some raw weather data for purposes of comparison.

Kathy

Kathy was another student whose comments helped to classify her as a member of the PreMade with Support group.

“I only used the weatherchannel when I first started forecasting. I would go and look at the weatherchannel and take that their forecasts for sure. I thought their forecasts were always correct.” [R4Q2 – Kathy]

“I started with the weatherchannel and whatever it said was right, I thought. I didn’t think the weatherchannel was ever incorrect, so I used all of the information that I could find on it.” [R4Q8 – Kathy]

“I started out by going to the surface maps to look at the temperatures, winds and fronts...The National Doppler Radar (weather channel) was my next stop because that gives me a good mental picture as to what I will be forecasting. I like to compare what different schools have to say about the weather compared to the weather channel . . . After recording all the data on these maps I go the weather channel. I go to the local weather to see the 7 day forecast.” [R1 – Kathy]

“I began by going to ISU, explanation and color analysis (a collection of surface maps). I opened up the map that said temperature and winds. This was so I could get a feel for what the weather was going to be somewhat like. After this, I went to University of Illinois and went under the surface column...The final and most helpful place I went to was the weather channel. I began with the local outlook and then the detailed outlook to give me a more exact number. The weather channel influenced me the most, but that is because the other places I looked were approximately in the same range.” [R2Q2 – Kathy]

The members of the PreMade with Support group showed that they relied heavily upon commercially produced forecasts for most of their forecast predictions. However, each of the students in the PreMade with Support group also used raw data sources to augment or strengthen their forecast predictions. For example, Arnold and Daryl used wind speed and direction information from surface maps, Ida used the meteogram from the University of

Wyoming for temperature predictions and Kathy said she used some types of surface maps for forecasting details.

Raw Data with Support Group

The Raw Data with Support group was characterized by a daring, though by no means reckless, willingness to use raw data tools to write forecasts. In stark contrast to the PreMade with Support group, Raw Data with Support group used commercial forecasting sites to provide some added details about their overall forecasts, not as a basis for the completed forecast. There were two students in the Raw Data with Support group at the beginning of the semester; Christine and Jane.

Christine

Christine was a second year university student and was pursuing a non-science degree. She reported her GPA was in the range of 3.0 – 3.5. To illustrate her willingness to assemble forecasts from raw data sources, but use pre-made forecasts at a minimum, I include the following quotes:

“For the temperature questions, I first look at the University of Wyoming Difax, DSM meteogram. I get a good sense for what the 18 Z temperature could be. I also check out the NCAR-RAP forecast. I have found that those surface temperature maps are usually a little high, so I take that into consideration. I also check a better source, at least what I think is a better source, the U[niversity] of Illinois temperature analysis.” [R2Q2 – Christine]

“I always look at the meteogram first and usually get a general idea of the temp, the wind speed, the cloud coverage, wind direction and so on and so forth. Then I look at the weather channel maps.” [R1Q2 – Christine]

“I use the University of Illinois radar maps that show cloudiness... Another source I use is the DSM Meteogram because it displays cloud coverage really well...” [R2Q3 – Christine]

“I only used the DSM meteogram to figure out the temp. and cloudiness. I only used the Weather Channel for front values. And I never really understood how to do advection, a lot of the time I would just guess or I would go by what the 850 or 500mb maps said.” [R4Q2 – Christine]

In keeping with the definition of the group, Christine used various raw data sources appropriately for specific purposes. She also utilized the Weather Channel for specific forecast details. Most frequently, she indicated using the Weather Channel for getting information about fronts and the movement of fronts.

Jane

Jane was a first year student and was pursuing a non-science degree. She reported her GPA was in the range of 3.0 – 3.5. In keeping with the definition of the group, Jane reported her early forecasting strategies in the following way:

“I did know there was a temperature map and so I would go there. It would show lines across isobars or whatnot across the map. It would show values for each line too and whatever line Iowa fell under, 40, 45, 70, 75, I would range it” [I3 – Jane]

“I consider the previous day’s temperature. I look for warm and cold fronts and cloud cover. The weather channel site is very helpful to consult. They are because they show fronts and clouds. If there are significant clouds, or winds moving fronts, those affect the values for the predicted temperatures” [R2Q2 – Jane]

“I would go to many sites trying to make sense out of the whole thing. I knew 12Z and 18Z were important, so anything marked with those I clicked on.” [R4Q2 – Jane]

“[To forecast winds I considered the influence of] One word, isobars. If they were close together it meant gusty winds and if they were further apart it meant calmer winds. Winds always blew from west to east, unless the position of a front on the Weather Channel’s “midday” map (compared to the ‘a.m.’ map) suggested to me that the wind was blowing any other way. After the lecture about knots, and the symbols used to denote wind speed, I was a much better wind forecaster.” [R4Q8 – Jane]

As can be seen from the descriptions offered by Christine and Jane, they were both rightly classified as members of the Raw Data with Support group. While Christine indicated she used the weather channel for only information about fronts and Jane used the Weather Channel for information about wind speed and direction, it was clear that they both used raw data sources to produce their forecasts.

Raw Data Group

The Raw Data group relied almost solely on weather models to produce their forecast predictions and never mentioned using the Weather Channel at all during their first several forecasts. Furthermore, the Raw Data group were more concerned with the interpretation of data than with the acquisition of pre-formed answers. There were three members of the Raw Data group; Ed, Fiona and Harold.

Ed

Ed was a first year meteorology student with a GPA in the range 3.0 – 3.5. He intended to pursue a career in meteorology, or at the least, meteorology-related. Ed was enrolled in another forecasting course at the same time as this course, which is normal for

meteorology majors. The following quote shows that Ed used only raw data sources to assemble his early forecasts:

“When deciding on what to forecast for my temperatures, i looked at the current surface maps, and what i thought would move into the area over the next 24 hours.”

[R1Q2 – Ed]

“I used the ETA temperature model at www.rap.ucar.edu to predict the 12z and 18z temps. By looking at the contours I estimated what it predicted the temps to be.”

[R2Q2 – Ed]

“I used the MSLP/winds map at www.rap.ucar.edu and the surface map to judge where there may be a front at [sic] tomorrow.” [R2Q5 – Ed]

Fiona

Fiona was a third year student enrolled in a science-related discipline. She reported her GPA within the range of 3.5 – 4.0. Her future career goals involved a science focus. The following quote from Fiona illustrates why she is a member of the Raw Data group.

“First I assumed the temperature tomorrow would be the same as today. I checked surface maps for current temps including forecasted highs and lows. Following that, I would look for fronts in the vicinity. I would also check the 700, 500, and 300 mb maps for signs of advection. Also I would look at satellite pictures and surface maps for cloud dispersal. These can influence the temp.” [R1Q2 – Fiona]

“First I went to the University of Wyoming page to look at the meteogram...I made sure to compare these values to the 12z and 18z temps on the meteogram. Then I also looked at the meteogram for wind direction and speed...” [R2Q2 – Fiona]

“The ISU surface maps for temperature and wind showed wind barbs crossing the isobars at a 90 degree angle. I assumed this meant there would be strong advection all day tomorrow. And since the wind was from the north, and it si colder there than here, it would be cold air advection.” [R2Q4 – Fiona]

And to provide a quick summary of Fiona’s data gathering strategies for clouds. she used “the university of Wyoming DSM meteogram for their station plots.” [R2Q3 – Fiona], and for fronts, she used “the ISU surface maps for fronts.” [R2Q5 – Fiona]

Harold

Harold was a graduate student in meteorology, whose career goals involved meteorology. Harold completed just enough of the activities to be included in the report. As a graduate student in meteorology, he was assumed to use all raw data, and his descriptions bear out this assumption.

“The wind direction is pretty basic from the standpoint of where the highs and lows are. It works by comparing where you are in comparison to where the highs and lows are. So the direction is pretty straightforward.” [I3 – Harold]

“I looked for shortwaves at the beginning of the semester when it was cold. It was pretty much orientation to the surface low. If you’re in the right area in comparison to the surface low you have a better chance for precipitation.” [I3 – Harold]

“If there’s less than two isobars across Iowa, there’s less than 5 miles per hour. If you have 2-3 isobars across Iowa, it’s five to ten miles per hour. Three to four isobars across would be 10 to 20. Since you get the five knot range on there (the scoring rubric), it falls in there quite often.” [I3 – Harold]

The Raw Data group used raw data sources exclusively to develop their forecasts at the beginning of the semester. There were some fundamental differences between the two members of the group with respect to which data sources were used. That finding was probably to be expected, because Harold may have been aware of resources not initially included on the weather products pages provided for the students.

Table 6. Changes in forecasting strategies at end of semester

<u>Name</u>	<u>Strategy</u>		<u>Change</u>
	<u>Early Semester</u>	<u>Late Semester</u>	
Arnold	PreMade with Support	Raw Data	+2
Beth	PreMade	PreMade	0
Christine	Raw Data with Support	Raw Data	+1
Daryl	PreMade with Support	PreMade with Support	0
Ed	Raw Data	Raw Data	0
Fiona	Raw Data	Raw Data	0
Greg	PreMade	PreMade with Support	+1
Harold	Raw Data	Raw Data	0
Ida	Pre Made with Support	Raw Data with Support	+1
Jane	Raw Data with Support	Raw Data with Support	0
Kathy	PreMade with Support	Raw Data with Support	+1

Late Forecasts

At the end of the semester, students in the study group were asked to describe their late forecasting strategies. Using the same analysis technique as described above, the students

in the case study group were placed into one of the four forecasting strategy groups. Table 6 summarizes the changes made to the forecasting strategies by each of the students in the case study group.

To analyze the differences exhibited with regard to strategy, only the students that made changes to their forecasting strategies over the course of the semester will be analyzed. To that end, only the five students in the case study group that made changes will be considered. Those five students were Arnold, Christine, Greg, Ida and Kathy.

Arnold

Arnold began the semester exhibiting forecasting features that made him a member of the PreMade with Support group. At the end of the semester, however, his responses suggested that his end-of-semester strategy would place him in the Raw Data strategy group. Not only did his strategy change, but he showed some evidence of monitoring his success as a forecaster as well. The following quote shows some evidence of the monitoring and change of strategies.

“When I first started out at the beginning of the semester, I really didn’t know anything, so I would just go straight to the Weather Channel and just take it right off there. Just to get the grade. As I started learning stuff, I... started using the graphs on the Iowa State network for the dew point temperatures and the wind direction and wind speed. I looked at those and I tried to make predictions as to what I would think would happen the next day. I started actually using graphs instead of being lazy about it. Throughout the semester, I just used those and I suppose I started getting better in my predictions as time went on because I would see what I predicted and what would actually happen the next day. From seeing how the temperature varies, I got actually a

better idea of what to look for in the temperature differences and on the graph and everything.” [I3 – Arnold]

When asked why he changed his forecasting strategy, Arnold replied:

“It was basically that I wanted to learn how to forecast. Any Joe Schmo can go look at the Weather Channel to get the information and stick it up there. But if I really wanted to know how to forecast for later on, I’d have to pay attention in class to understand how it works and that way I could really forecast. It was really interesting what I changed because it was more interesting.” [I3 – Arnold]

However, for all of his self-reported monitoring, Arnold made some very serious misstatements about his ability to forecast accurately. For example, when asked how well he forecasted in the beginning of the semester, Arnold replied that his first five forecasts earned him “29 or 30 points” [I3 – Arnold] out of 36. Then at the end of the semester, he reported his most recent five forecasts were earning him “probably around 34” [I3 – Arnold] points out of 36. With forecast scores such as he reported, he should have had no problem earning a high grade in the course. However, these facts are in serious doubt. Reviewing his forecast scores revealed that his performance began in the 24-26 out of 36 range and ended in the 26-30 range. Moreover, his 18 total forecasts were insufficient to earn him a high grade. His final grade was a D.

Christine

At the beginning of the semester, Christine used mostly raw data sources to create her forecasts. At the end of the semester, she had changed her strategy sufficiently so she was only using raw data sources. She was also monitoring her strategy more closely by the end of

the semester. The following two quotes seem to give some support to the assertion that she was closely monitoring her strategy:

“I don’t really forecast the 18z temperature differently because I usually had that one pretty close. Although, I do a little more investigation into the 12 z temp. I know it’s important to see where the fronts are or the direction the air is coming from in order to see which direction the temperature is likely to go.” [R4Q4 – Christine] (describing her temperature forecasting strategy)

“Now I check more for the magnitude of the front and what is the most likely form of precipitation that could come from it. I learned that the stability has to do with thunderstorms and other systems like that, of which we really wouldn’t have seen much of anyway before now, since now it’s spring.” [R4Q7 – Christine] (describing how her precipitation forecasting strategy changed)

When asked to describe her performance on forecasts at the beginning of the semester as opposed to the end of the semester, Christine said that her average forecast score for the first five forecasts was “22 or 24” [I3 – Christine] out of 36. Her average was closer to 26, but her estimate was close. For the final five forecasts, she indicated that her average was “probably 28 or 30” out of 36 points. Her actual average was very close to 30. These responses indicated that perhaps Christine was closely monitoring her strategy throughout the semester, which was one of the intentions of the study. Christine finished the course with a grade of A.

Greg

Greg began the semester with a strategy that would qualify as relying on PreMade forecasting sources. By the end of the semester, Greg’s strategy was comprised of using

mostly PreMade source information with a bit of Raw Data included. Greg described his precipitation forecasting strategy in the following quotes, early semester strategy first and late semester second:

“Early in the semester, it was during winter and usually there wasn’t any (precipitation). So I just look for something to put in there. I’d watch the news, of course, and look at the Weather Channel site to see if there’s going to be any (precipitation), but usually there wasn’t. It’s not like in the Spring, where it can rain for a week and a half straight.” [I3 – Greg]

“I definitely use the fronts map on the Weather Channel web page because you can see if anything is going to come in. I don’t think that it is so much that I changed my pattern but I just know what to look for now...Not that I use the news any less. because I’ll always go check it now. And I’ll go to the Weather Channel site since it seems to be accurate.” [I3 – Greg]

Greg also reported he monitored his forecasting accuracy fairly closely. He indicated that his first several forecasts “got better over the first four or five, but I got a lot of mid-20s...because the weather in the winter doesn’t change that much.” [I3 – Greg]. He was correct in this assessment. He earned a great number of scores in the 22-24 range throughout the semester. His late semester forecasts were earning between 34 and 36 points. On this measure, Greg was slightly less accurate. That is, though he did earn several forecasts above 30 points, his last five forecasts (at the time of the third interview), were in the range of 24-32, and most of the scores in that range were 30s. Greg finished the course with an A.

Ida

Ida's early semester strategies were classified as PreMade with support and her late semester strategies were Raw Data with Support. The following quotes help indicate how Ida changed her winds strategy:

"For winds I think I just kind of noticed what was the day before and also looked on the Weather Channel. But I did not know how to do the direction of the wind. I just guessed." [I3 – Ida]

"I look at the surface map...I actually still don't do this great, but if I can find a map that has isobars on it, I know that the wind blows parallel to the isobars, and that the wind goes counter clockwise around a low and clockwise around a high, so it's just a matter of finding that map." [I3 – Ida]

Ida also suggested that she was aware of how she had changed some of her forecasting strategies when she said, "I definitely look stuff up and I know what to look for and I spend more time on it." [I3 – Ida] Ida reported that her average early forecast scored 24 out of 36 points. She was very close with this estimate of how things were in the beginning of the semester for her. She also mentioned that her late semester forecast average score was "29 or 28" out of 36. Her actual score was somewhere in the range of 22-32, so her estimate was fairly close. Ida finished the course with a grade of A.

Kathy

Kathy began the semester with a PreMade with Support forecasting strategy and ended the semester with a Raw Data with support forecasting strategy. She also seemed to be maintaining a close understanding of her forecasting strategy, as the following quotes attest:

"Now I double check all of my forecasts, sometimes I check it with at least a couple of different sites. I like to go to the Iowa State University site and look at the surface

analysis site. The U.S. weather and fronts is very helpful for fronts because they are very interesting and then I can compare those predictions with the Weather Channel's. I also look at the temp and winds page because it gives me a good approximation of the wind speed and direction." [R4Q2 – Kathy]

Kathy seemed to believe that the more sites visited, the better. The following two quotes address her strategies to forecast temperature and precipitation, respectively.

"I use many of the sites given to me to forecast temperature. There are many pages you can go to when you are on the Weather Channel site. I like to double check my answers with other universities and the weather channel. I think that the people creating the weather channel are a little more qualified than students at the Universities." [R4Q4 – Kathy]

"The more you research about precipitation, the more accurate you can be. You must try to use as many resources given to you as possible. The resources are there for you, so you might as well take advantage of them" [R4Q4 – Kathy]

Kathy's overall average forecast score was 28 out of 36, which is fairly good. Her first five forecasts averaged 28 points, and her final five forecasts scored between 29 and 30 points. She finished the course with a B+.

Qualitative Summary

The qualitative data was collected to help identify patterns in the case study group students' forecasting strategies and to identify instances where the students in the case study group changed strategies. In the cases where students made changes to their forecasting strategies, qualitative data were analyzed to discover if the student provided any rationales for the changes. Our assumption was that metacognition, in the form of reflective thinking

about forecasting, helped students to identify areas where their forecasting strategies were producing inaccurate weather forecasts. From this standpoint, the study methodology helped to elicit statements from students that indicated changes in forecasting strategies.

Each student in the case study group completed several reflective journal entries and also at least one interview about his forecasting strategy. Each of these activities provided a snapshot of how each student viewed the process of forecast writing, how each student completed the process and where each saw areas where improvements could be made to the forecasting strategy to make their forecasting strategy more effective and accurate. In combination, the data provided a more complex summary of each student's strategies, since the strategies were viewed from several different angles and from differing levels of complexity.

Data analysis identified five students who made substantial changes to their forecasting strategy. Each of the students who made substantial changes to forecasting strategies incorporated more raw data into their forecast predictions.

Quantitative Summary

Quantitative data were collected to make judgments about whether the case group members made improvements to their forecast strategies over the course of the semester. To make comparisons between the groups, data relating to epistemology and GPA were collected with the help of a survey given during the initial class meeting. Other comparisons were drawn based upon raw numbers of forecasts written, average weather forecast scores and final grades for each student in both groups.

Course v. Case Study Group

The qualitative results have shown that the instructional activities were able to get students to assess their personal forecasting strategies. In this quantitative results section, the attention turns to whether students in the study group benefited quantitatively as a result of the time spent thinking metacognitively. To address this question, several comparisons were drawn between students in the case study group and the rest of the students in the course.

Comparisons were drawn between two unequal-sized groups; the study group participants ($n = 11$) and the rest of the class ($n = 212$). The comparisons consisted of relationships between incoming GPA, final grade, number of forecasts written, overall average forecast score and number of forecasts written. Table 7 summarizes this information.

GPA

Data relating to incoming GPA were collected during the first course meeting. There were five possible ranges, $5 = 4.0 - 3.5$, $4 = 3.5 - 3.0$, $3 = 3.0 - 2.5$, $2 = 2.5 - 2.0$ and $1 = \text{less than } 2.0$. The overall course GPA mean was 3.10 ($SD = 2.32$) on this scale, which is somewhere in the $3.0 - 2.5$ range on a four point scale. The case study group mean was 3.30 ($SD = 2.32$), and the resulting rest of the course was 3.09 ($SD = 2.32$), but the difference was not significant ($t = 0.545$, $p = 0.586$). This lack of significant difference indicated that the study group did not differ significantly with respect to GPA when compared to the rest of the class.

Number of Forecasts

The overall course average for number of forecasts was 34.8 ($SD = 18.88$). When comparing the students in the case study group with the rest of the course, the case study group had higher values for average numbers of forecasts (39.70, $SD = 11.91$) than the rest of the class (34.54, $SD = 17.06$), but the difference was non-significant ($t = 0.944$, $p = 0.346$). This finding

tends to indicate that the study-related activities did not have a significant effect on the number of forecasts written by students in the case study group.

Table 7. Study data summary

		Number of	Average	Final
<u>Group</u>	<u>GPA (SD)</u>	<u>Forecasts (SD)</u>	<u>Forecast (SD)</u>	<u>Grade (SD)</u>
Entire Course	3.10 (2.32)	34.77 (16.88)	21.14 (8.53)	66.4 (23.06)
Course- Case	3.09 (2.32)	34.50 (17.06)	20.98 (8.67)	65.8 (23.35)
Case study group	3.30 (2.32)	39.70 (11.91)	24.52 (3.38)	77.9 (10.99)

Epistemology

The epistemology score for each student was determined by analyzing their responses to the epistemology sections of the initial class survey. The case study group had a mean epistemology score of 102.44 (SD = 6.78), while the rest of the course had a mean score of 103.73 (SD = 10.20). The difference in means was also not statistically significant ($t = -0.375$, $p=0.708$). This finding shows that the case study group and the rest of the students in the course were not significantly different with respect to epistemology.

Final Score

The case study group's mean final score was 77.89 (SD = 10.99) percent and the rest of the course's mean grade was 65.87 (SD = 23.35). The difference of 12.02 was found to be significant ($t = 3.140$, $p = 0.008$), when relying on the findings of a Levene's test of equality of variances. Because the case study group was so small in comparison with the rest of the course, further tests were run to establish the validity of this finding. An analysis of covariance on final grade with group membership and GPA as covariates showed that the

difference based on group membership alone was non-significant ($F = 2.176$, $p=0.142$). A Mann-Whitney U test also showed that the differences in final grade due to group membership were non-significant ($p = 0.084$). Thus, I determined that the differences in final grade with respect to group membership were not significant.

Quantitative Discussion

The quantitative data were analyzed to draw comparisons and contrasts between the study group and the students in the rest of the course. However, none of the measures that were analyzed suggested that the students in the case study group performed significantly better than the students in the rest of the class. Though the case study group had numerically higher scores for average forecast score, number of forecasts written and final grade, none of the differences were found to be significant.

Discussion

The research questions were:

1. Do metacognitive learning and thinking activities tend to encourage novice weather forecasters to change their weather forecasting strategies?
2. Do students using metacognitive learning strategies adopt accurate weather forecasting strategies?
 - a. Do individuals make improvements to their forecasting strategies and thus increase their forecast scores?
 - b. Do students using metacognitive and reflective learning strategies produce forecasts that are more accurate than their peers'?

To answer research question number one, qualitative data analysis techniques were used. Within the case study group, each of the eleven participants showed evidence of

monitoring their forecasting strategies. Five of the eleven students adopted forecasting strategies that incorporated increasing levels of raw forecasting data (forecast maps, interpretation of models, etc.), as summarized in table 6. According to the levels that I established, the change toward including more raw data was moderate. That is, nobody in the case study group began the course using pre-made forecasts and ended the course using only raw weather products.

There were six students who did not change their strategies throughout the semester. Of these, three students were already using raw weather products, and thus there was a “ceiling effect” of a sort with regard to their ability to adopt more raw weather products. Overall, the students in the case study group, with the exception of one student – Beth – adopted raw weather products into their forecasting strategies by the end of the semester.

The answer to research question one is yes. The students in the case study group used metacognitive learning and thinking strategies and were often able to critically assess their solution strategies. The case study group students also tended to monitor their forecasting abilities to identify larger trends. That is, students were able to identify areas where their forecasting strategies were lacking, and as a result, the students moved to change the ineffective strategies over the course of the semester. The metacognitive strategies were not perfect, however. Three students chose not to change their forecasting strategies, and three others were unable to adopt more raw data into their forecasts.

To answer both parts of the second research question, both quantitative and qualitative data were analyzed. First, the students’ reflective journals provided some insight into their forecasting strategies; how they were established, how they developed and how students used them differently at the end of the semester. Second, quantitative data were

analyzed to provide comparisons within the individual students in the case study group (to answer part A) and between the students in the case study group and their peers enrolled in the course (to answer part B).

The answer to question 2a is no. The effect on increase in forecast score or increased accuracy of forecasting strategies is lost because of the course-wide effect relating to numbers of forecasts written. That is, students who wrote more than the minimum 25 forecasts had higher average forecasting scores, regardless of prompts. Although the case study group averaged 39.70 (SD = 11.91) forecasts and the rest of the students enrolled in the course averaged 34.54 (SD = 17.06), the difference was non-significant..

The students in the case study group averaged 24.52 points on the scores of all forecasts (not just the best 25), while their peers in the rest of the course scored 20.98 points on average. This finding (though also non-significant) does lend some support for the notion that the students in the case study group were both motivated toward improving their forecasting strategies and writing forecasts more often than their peers.

The study was designed to investigate whether metacognitive learning and thinking strategies were effective within a large lecture format university course. The study was also designed to determine if journaling and interviews could foster the metacognitive nature of students' thinking with respect to monitoring their weather forecasting strategies. Results from the qualitative analysis of the data indicated that metacognitive learning and thinking prompts were effective in eliciting metacognition from university-aged students. Moreover, the techniques helped to reveal how students changed their strategies, and the rationales they used for changing forecasting strategies. In most cases, the members of the case study group reported that the old forecasting strategy did not provide enough accurate information to

result in an accurate forecast, and was abandoned in favor of a strategy that did provide more accurate forecasting information. However, as figure 1 showed, the highest average forecast scores were written prior to the midpoint of the semester. The disparity between actual performance and perceived performance may indicate a maturing familiarity with the forecasting process, rather than simply writing more accurate forecasts.

This Study and Previous Studies

Both Blank (2000) and Martin et al. (2000) investigated the use of metacognition enhancing activities within science courses. Blank's (2000) study investigated the use of a metacognitive learning cycle to organize thinking about ecology in a secondary school environment, while the Martin et al. (2000) study looked at the effect of concept mapping on the ability of university students of varying thinking abilities to better understand marine biology. Blank's study found that a metacognition-focused strategy monitoring activity, where students were consistently evaluating their strategies and making changes to them, was more effective than an activity that asked students to only identify their personal ideas and then write hypotheses consistent with the personal ideas.

Martin et al. (2000) found that successful learners in natural sciences may be able to concurrently develop, monitor, regulate and control their thinking processes about natural science. Furthermore, the researchers reported that simple awareness of personal learning strategies was not enough to assure understanding of the content. Rather, they found that awareness was the first requisite step toward monitoring, regulation and control. Their study found that students who could monitor, regulate and control their thinking and beliefs about marine biology also tended to perform better in their course than could students who were merely aware of their ideas with regard to marine biology.

Similarly, White and Frederiksen (1998) discussed how scaffolding activities were effective at teaching students about physical science, particularly about Newton's Laws of Motion. Their ThinkerTools curriculum allowed students to test and organize their thinking about Motion by using computerized models of Newtonian Motion. Their curriculum was effective at encouraging students to review and reflect upon their previous notions of Motion while creating or developing more accurate notions of Motion.

This study investigated how students used reflective activities within the context of a large introductory lecture-format University meteorology course to monitor and evaluate their weather forecasting strategies. The results of the study indicated that students in the case study group were consciously aware of their forecasting strategies, how their initial forecasting strategies changed over the duration of the semester and furthermore, and were able to provide rationales for changing their strategies.

Within the context of the previous studies, the current study suggests that metacognition prompting activities –such as reflective journaling and limited interviewing - are somewhat effective within large, lecture format courses. To reach this conclusion, we found that the students in the case study group met Martin, et al.'s (2000) criteria for deeper understanding using some of the techniques described in Blank (2000). That is, students in the current case study group were simultaneously able to monitor, regulate and control their thinking and strategies regarding weather forecasting using methods that encouraged the case study group students to consistently make judgements about the value and effectiveness of their current strategies.

Metacognition in This Study and in Other Studies

This study lends some support for both previous and current theories of metacognition. For example, the study affirms Flavell's dual component theory of metacognition (1979). The students in the study exhibited metacomprehension when they made changes to their forecasting strategies to make them more effective, and they exhibited metamemory by recalling appropriate and effective strategies when conditions dictated.

In the context of this study, the early reflective activities focused on encouraging students to ask questions about their strategies and the effectiveness of those strategies. Later activities asked students to compare early strategies with late strategies and to rationalize the differences between the two sets of strategies. The qualitative results of the study indicated that students were monitoring their weather forecasting strategies and making changes to the strategies to make them more effective. The quantitative results showed that the case study group did not perform significantly better than the rest of the students in the course with respect to final grade, number of forecasts written or average forecast score.

Further Research

This study has shown some promise in the area of science education, especially with respect to large lecture format university science courses. Several further research studies are appropriate, using similar introductory lecture courses as the study sample. For example, the effect of the journaling activities - in absence of the interviews – on the students' developing understanding of meteorology may be investigated. Such a study would investigate how students described their conceptions in journaling exercises at regular intervals throughout the semester. Such journaling activities would place a premium on students describing their

conceptions in terms of its current form, how the conception has changed over time and why the conception has changed, if necessary.

Another study would investigate how students describe how their conceptions change while participating in focus group interviews about meteorology topics. Though individual, clinical interviews were good elicitors of information with regard to development of conceptions, they are simply too time intensive to be effective for studying very large samples of students. In this study, focus group discussions would take place at regular intervals during the semester and would focus on students describing and comparing their current forecasting strategies with other students. The study would further investigate how students in the focus groups performed in the course with regard to forecasting accuracy and other assessments, such as quizzes and exams, in comparison with the other students in the course.

Instructional Implications

This study seems to indicate that some type of reflective or metacognitive activities can help students even in large, lecture-format courses at the University-level. The course described in the study had a semester-long assignment to write weather forecasts. The course-long forecasting assignment was necessary for the study because it gave the participants multiple opportunities to apply their solution strategies and thus to notice flaws in the strategy. Gunstone, Gray and Searle (1992) reported that keeping students informed and aware of their personal concepts and changes being made to those concepts was central to the value students placed on the instructional activity intended to bring about conceptual change. The reflective activities in the study asked students to make some decisions about

their forecasting strategies at various points in the semester and to make judgements about the effectiveness of their strategies.

Further instructional studies might include similar reflective activities within the course. Some of the reflective activities might include journaling or small-group activities designed to encourage descriptions and comparisons of science conceptions. Other activities might include reconceptualizing the lecture as a 300-person discussion group, rather than a one-way information transfer. In such a reconceptualization students would be organized in groups of 20-30 and would, as a group attempt to solve problems by reaching consensus on solution strategies and working through the solution as a group.

However in a realistic scenario, students might be required to describe their solution strategies at the beginning of the semester, and again at two to three other times during the semester. A final exercise would require the students to describe their personal conceptions at the beginning of the course, how they appear at the end of the course, and provide a rationale for how they changed over the period of the course.

Study Limitations

There are seven limitations in the design of this study, which had potential affects on data generation, data analysis and thus the results and conclusions of the study. The limitations were: 1) the survey; 2) the differences in techniques used to create the case study group and the technique actually used to create the case study group; 3) the techniques used to elicit the student journaling entries; 4) the stipend given to the interviewees; 5) the interview protocols; 6) the unfamiliar interviewer; 7) the qualitative analysis methods used to group students based on similarities in forecasting strategies, and; 8) the techniques used to

describe quantitative differences between the case study group and the rest of the students enrolled in the course.

The survey contained two potential weaknesses. The first weakness involved students reporting their GPAs within a pre-specified range. The question about GPA supposed that students knew what their actual GPA was, and second that they were honestly reporting their actual GPA range. While a self-report measure of GPA on an abbreviated scale is a potential weakness, the data collected in the survey suggested that the measure reflected the students' actual GPA reasonably well. The GPA scale correlated substantially with students' final grade percentage ($r = 0.66$ for the students in the case study group, $r = 0.55$ for the students not in the case study group). Moreover, GPA was the strongest correlate of final course score among the individual difference variables assessed. These relationships suggest that the GPA measure obtained through survey responses behaved similarly to the way a measure of actual GPA performance would be expected to behave. Thus, it seems likely that the self-reported GPA measure provided a reasonably valid, and easily obtained, estimate of the students' actual GPAs.

The second weakness in the survey was in the epistemology abstract from Schommer (1990, 1993). The weakness is an assumption that the 30 epistemology questions in the survey were as reliable and consistent as Schommer's original 63 epistemology questions. However, the same 30 question abstract was used previously by Haselhuhn (1995) to measure epistemology with similar groups of students. In the present study, the students with better GPAs had higher scores on the epistemology measure. The abbreviated epistemology survey provided similar results with respect to epistemology and final grade as would be expected from the whole epistemology survey. Taken together, the data suggested that the

abbreviated epistemology measure captured meaningful aspects of the students' epistemological beliefs.

The original case study group was intended to consist of two groups of students based on academic major and GPA. The first group was supposed to consist of science majors that had high GPAs. The second group was supposed to consist of non-science majors with low GPAs. The actual case study group experienced a high rate of attrition and was augmented with volunteers from the general class population. As such, the study was not fundamentally changed with respect to the study activities completed. However, the study was slightly changed with regard to the make up of the participant group, and thus some of the intended contrasts were not analyzed. The study data suggested that the members of the case study group were not significantly different on measures relating to incoming GPA or epistemology score: two measures that were found to correlate highly with final course score. The course instructor encouraged all students in the course to write as many forecasts as possible, because such a strategy increases the likelihood of earning points due to well-written forecasts. The study activities also encouraged the case study group participants to assess personal performance and to rationalize changing forecasting strategies. As such, the data showed that the students in the case study group wrote forecasts that earned average scores that were higher than the students in the rest of the course.

The reflective journaling activities were created to encourage reflection about forecasting strategies and their effectiveness. Though most students in the case study group completed the reflective activities as they were intended, some of the students either did not complete the reflective activities as intended or neglected to complete them altogether. While some of the students in the case study group did not complete all of the study activities,

changes with respect to personal forecasting strategy were noted based on responses given to the activities that were completed. Though an even deeper and richer picture could have been captured if all the students completed all of the activities, realistic expectations suggested that the data we collected was sufficient to answer the research questions.

Each student in the case study group was compensated for his time after each interview he completed. Though the stipend was promised to the student even if the interview was not thoroughly completed, the stipend may have affected the way the student responded to the questions posed during the interviews. As such, some of the responses on the part of the interviewee may have been slightly changed due to the stipend. Though the stipend may have affected the way that the student responded to some of the interview questions, the study also used triangulation techniques. Triangulation means that the results from several data sources were compared. Using such techniques would help to identify interview responses that were substantially different from responses given to questions of different types (such as journal entries). The effect of the triangulation was to mediate the effect of any interview responses that may have arisen due to payment, and/or desire to provide an answer that the interviewer wanted to hear.

The interview protocols used were created to elicit details about individuals' forecasting strategies, changes that the individual made to the forecasting strategies over the course term and rationales that the individuals provided for the changes. The protocols themselves may not have elicited a faithful representation of the students' thinking and rationalization process, and as such, the protocols may have elicited unrepresentative information about the students' forecasting strategies. Furthermore, the protocols themselves may have encouraged students to manufacture changes to their forecast strategy descriptions.

That is, the interviewees may have wanted to appear cooperative, or they may have felt that descriptions of their strategy changes were required for participation in the case study group. Though the interview protocols may have helped to elicit responses that were inconsistent with the students' personal understandings of their forecasting strategies, the study included various other methods that helped to mediate these effects. For example, the reflective journaling prompts simply asked the students to describe their forecasting strategies and to address how they changed, or should be changed to produce a more accurate forecast. Since the responses collected from all students within the case study group were relatively consistent, with respect to each individual, the interview protocols were assumed to have had little additional deleterious effect on the students' ability to respond reasonably to the interview questions posed.

The interviewer was unknown to all of the members of the case study group and the course as a whole. As such, the students in the case study group may have not been willing to provide details about their forecasting strategies to him. Moreover, students may have decided during the initial class meetings that they were unwilling to participate in the case study group because of the unfamiliarity of the interviewer. This potential weakness may have limited the potential pool of participants. If this study was purely quantitative, the very small number of participants in the case study group may have posed a huge problem when trying to determine how the study activities had an effect on each students' performance in the course. The study included several different types of data collected using various different means and analyzed in a holistic manner. Furthermore, most of the data was collected in the absence of the interviewer. For the purposes of this study, the number of willing participants was sufficient.

Qualitative methods were used to analyze the data generated by the various study activities. Aside from using a constant comparison framework, some of the techniques used to analyze specific pieces of information were created specifically for the purposes of this study and may not have general applicability. The qualitative techniques may not have identified some trends evident in the students' descriptions of their forecasting strategies, or may have incorrectly identified trends where none actually existed.

Lessons Learned

Some lessons learned in one field can help direct some of the progress made in another related field. For example, Gunstone, Gray and Searle (1992) reported that keeping students informed and aware of their personal concepts and changes being made to those concepts was central to the value students placed on the instructional activity intended to bring about conceptual change. In the absence of this awareness, students still tended to reap the conceptual change benefits, but were unwilling to attribute the improvement to the instructional activity.

The study included some methods that helped students engaging in learning about meteorology keep the burgeoning development of personal forecasting strategies foremost in their minds. I also determined that part of the reason for the case study group's strategy monitoring may have been due to writing a large number of forecasts. That is, the students in the case study group had multiple opportunities to reflect on their strategies. Writing as many forecasts as possible during the course of the semester was a strategy available to the whole class, however.

Future directions for research are opened as a result of this study. In contrast to previous studies, the study described here suggests that metacognitive techniques are

effective eliciting metacognitive thinking responses from students in large lecture courses. Moreover, since many students entering University are often in several large lecture classes, developing and testing methods for use in such courses may be very valuable. A future implementation of the study presented here may look at isolating the role of interviews in the improvements noted from students in the case study. That is, since interviewing several hundred students may be impractical, a study implementation that does not use interviews, but does use journaling activities to encourage metacognition might help to shed light on the role of interviews in the metacognition artifacts discovered.

Further metacognitive research studies in large lecture format course may also include an emphasis on longitudinal methods to create comparisons between students using metacognitive techniques in science disciplines and students not using such techniques to learn about science. That is, longitudinal methods might shed a great deal of light upon the long-term consequences of using reflective activities with strategy monitoring exercises.

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CHAPTER 4. GENERAL CONCLUSIONS

The purpose of this chapter is to summarize the papers included in this dissertation. In this chapter, a brief summary of each of the papers is included followed by a discussion of the implications of the study for further uses of metacognition in science education and a set of general conclusions.

General Discussion

Literature Review

Chapter two of this dissertation consisted of a review paper that summarized the use of metacognitive learning and thinking strategies within general education environments, as well as their use within instructional science environments of various descriptions. Chapter two helped to point out where the current use of metacognitive learning and thinking strategies had been extensively researched, and where metacognitive techniques are still being developed for instructional use.

The existing literature concerning metacognitive learning and thinking strategies indicated that various factors weighed heavily on the effectiveness of metacognitive techniques. Among these factors are: content expertise, various measures relating to cognitive abilities, age differences, content knowledge and epistemology and the level of instructor metacognition.

Extensive research has been carried out with younger students using metacognitive techniques while they are learning to read or learning about mathematics. Less research on metacognitive techniques has been reported based upon students in secondary or university classrooms. Within the entire body of research, very few studies looked at the use of

metacognitive techniques with secondary-aged or university-aged students learning about science.

The body of literature that investigated the use of metacognitive learning and teaching strategies with secondary- and university-aged students indicated that various methods were helpful encouraging students to think using metacognitive prompts and other reflective thinking techniques. Among the helpful methods were concept mapping (Martin et al., 2000), computerized simulations (White and Frederiksen, 1998) and purposive, reflective questioning (Blank, 2000).

The review paper suggested that the use of metacognitive learning and thinking strategies could be effective with university-aged students. However, no studies were found that looked at the use of such techniques with the large, lecture-format courses that many incoming university students must take as introductions to any science discipline.

Study Paper

Chapter three consisted of a paper written for a research-oriented science education journal. The paper reported a study conducted at Iowa State University that was designed to determine if metacognitive thinking prompts were effective for students enrolled in a large, lecture-format introductory science course. The course was selected for two reasons: 1) because of the willingness of the instructor to incorporate metacognitive prompts into the course, and; 2) because the instructor was using computerized tools to help facilitate student monitoring of their forecasting accuracy, among other things.

The study group consisted of a group of eleven students that were investigated closely. The students in the study group completed all of the required course activities, but also completed several reflective journaling activities and most participated in at least two

interviews. The format of the interview was designed to get information about each student's forecasting strategy, how that strategy was formed and developed over time and whether the forecast strategy was effective for writing accurate weather forecasts.

The conclusions of the study indicated that the students in the study group wrote more total forecasts on average than the average number written by the other students in the course as a whole. The correlation between number of forecasts written and final grade was quite strong ($0.801, p < 0.001$). Other findings suggested that incoming GPA and student epistemology were each highly correlated with final score (GPA: $r = 0.549, p < 0.001$); epistemology: $r = 0.143, p = 0.034$).

Future directions for research were revealed as a result of this study. In contrast to previous studies, the study described here suggests that metacognitive techniques are effective eliciting metacognitive thinking responses from students in large lecture courses. Moreover, since many students entering University are often in several large lecture classes, developing and testing methods for use in such courses may be very valuable.

Further metacognitive research studies in large lecture format course may also include an emphasis on longitudinal methods to create comparisons between students using metacognitive techniques in science disciplines and students not using such techniques to learn about science. That is, longitudinal methods might shed a great deal of light upon the long-term consequences of using reflective activities with strategy monitoring exercises.

General Conclusions

This dissertation reported the current state of relevant literature with regard to the use of metacognitive learning and thinking strategies in various types of science learning environments. The literature review revealed that metacognitive learning and thinking

strategies had general effectiveness when used within science courses at the secondary education level or with lower enrollment universities level science courses. We were unable to locate any research studies that investigated the use of such metacognitive learning and thinking prompts with students enrolled in large lecture format introductory science courses .

The dissertation also reported a study investigating the use of metacognitive thinking prompts with university age students enrolled in introductory large lecture format science course. The results of this study indicated that metacognitive learning and thinking prompts were somewhat effective in encouraging students to evaluate and reevaluate their science conceptions. Further studies investigating the use of metacognitive prompts with students enrolled in large lecture format courses are encouraged, because of the high number of such courses offered on college campuses.

APPENDIX A. SURVEY FORM

To begin, please fill in the bubbles on the left side of the scan sheet in the following manner: Under the Name field, please enter your name, Family Name first and First Name last. Place one letter in each column. Thus, if your name is Sue Smith, you should fill in the bubbles. from left to right, SMITH SUE. Be sure to leave a space between your family name and first name.

Encode your Social Security Number in the section marked identification number.

1. I give permission for information collected from me to be used in published research reports based upon this evaluation.
a. Yes, I give permission b. No, I do not give permission.
2. Please indicate your gender by marking a if you are male, and b if you are female
a. Male b. female
3. Please indicate your major by selecting your college from the choices listed:
a. LAS b. Education c. Business d. Engineering E. None of the above
4. If you marked E on the previous question, select your college from the choices listed:
a. Agriculture b. FCS c. Design d. Vet Med E. None of the Above
5. Please indicate which year in school you are:
a. Freshman b. Sophomore c. Junior d. Senior e. Fifth-year Senior
6. Please select your GPA from the ranges listed:
a. 4.0- 3.5 b. 3.49- 3.0 c. 2.99- 2.5 d. 2.49- 2.0 e. less than 2.0
7. Do you believe your future career will focus on science, engineering, or technologies?
a. Yes b. No

The following three questions will use a five point scale for responding. On this scale:
1 = Very interested, 2 = Interested, 3 = Neutral, 4 = Disinterested, 5 = Very disinterested

8. Overall, how do you rate your interest in the biological sciences?
9. Overall, how do you rate your interest in the physical sciences?
10. Overall, how do you rate your interest in the field of meteorology?
11. Why are you enrolled in MT206?
a. It is required in my degree program b. It is an elective c. I don't know

On the remaining items, please use the following five point scale for responses:

1 = Agree, 2 = Somewhat agree, 3 = Neutral, 4= Somewhat disagree, 5 = Disagree

12. It is hard to learn from a textbook unless you start at the beginning and learn one chapter at a time.
13. If I can't understand something right away, I keep on trying.
14. The best thing about science class is that most problems have only one right answer.
15. You will get mixed up if you try to combine new ideas in a textbook with what you already know.
16. I like it when experts disagree.
17. Some people are just born smart, others are born dumb.
18. Being a good student generally involves memorizing facts.
19. What students learn from a textbook depends on how they study it.
20. You can not learn anything more from a textbook by reading it twice.
21. Truth never changes.
22. A class in study skills would probably help slow learners.
23. Thinking about what a textbook says is more important than memorizing what a textbook says.
24. Working hard on a difficult problem only pays off for the really smart students.
25. An expert is someone who is really born smart at something.
26. Successful students understand things quickly.
27. In order to understand what a sentence really means, you have to know the whole story behind it.
28. I really do not like listening to teachers who can not seem to make up their minds about what they really believe.
29. If I can not understand something quickly, it usually means I will never understand it.
30. Scientists can get to the truth if they just keep searching for it.
31. Most words have one clear meaning.
32. If I am ever going to be able to understand something, it will make sense to me the first time I hear it.
33. Today's facts may be tomorrow's fiction.
34. To me, studying means getting the big ideas from the textbook rather than the details.
35. The really smart students don't have to work hard to do well in school.
36. There is only one thing you can be sure of, that nothing is sure.
37. If I find the time to re-read a textbook chapter, I get a lot more out of it the second time.

- 38. Students who are "average" in school will remain "average" for the rest of their lives.
- 39. If scientists try hard enough, they can find the truth to almost anything.
- 40. Getting ahead takes a lot of work.
- 41. The knowledge of "how to study" is usually learned as we grow older.

APPENDIX B. FORECASTING FORM

1. Reporting Station (4 letter code) KDSM

Daytime Temperature

2. 18 Z Temperature _____ F

Temperature Influences

3. For 18Z tomorrow, I predict cloudiness will:

- hold down the daytime temperature
- not affect the daytime temperature

4. Advection may also change temperature. I predict 18Z temperature change will:

- be affected by warm air advection
- be affected by cold air advection
- not be significantly affected by advection

5. A frontal passage by 18Z tomorrow may also affect the temperature. I predict there will have been the passage of:

- a warm front
- a cold front
- an occluded front
- a stationary front
- no front

within 140 miles of the recording site.

Nighttime Temperature

6. 12Z Temperature _____ F

Temperature Influences

7. Advection may also change temperature. I predict 12Z temperature change will:

- be affected by warm air advection
- be affected by cold air advection
- not be significantly affected by advection

8. A frontal passage by 12Z tomorrow may also affect the temperature. I predict there will have been the passage of:

- a warm front
- a cold front
- an occluded front
- a stationary front
- no front

within 140 miles of the reporting site.

9. Cloud cover to inhibit radiational cooling tonight

- will be significant
- will not be significant

Precipitation

10. Will there be precipitation between 12Z tomorrow and 12Z the next day?

- Yes
- No

Precipitation Influences

11. The following factors will favor precipitation during the forecast period: (You may NEED to select more than one)

- Moisture Supply
- Frontal Position
- Unstable Atmosphere

Wind

12. Wind Speed at 18Z: ____ (knots)

13. Wind Direction at 18Z (Select from N, NE, E, SE, S, SW, W, NW)

APPENDIX C. REFLECTIVE QUESTIONS

Reflective Activity #1

Qnumber	Text
1	Enter the forecast day you are using for this exercise
2	For the forecast you completed, describe the process you used to forecast the temperature. For each question (2-9), write down what you did to arrive at your answer (for example, the maps you consulted, the guesses you made, the hunches you had). If your answer was incorrect, what do you think you might have done differently to answer the question correctly?
3	What questions do you have?

Reflective Activity #2 and #3

Qnumber	Text
1	Enter the forecast day you are using for this exercise
2	Questions 2 and 6 on your forecast sheet ask for the temperature for 18z and 12z respectively. Describe the process you used to forecast the temperatures. Identify the resources you used, describe why each of the resources was important and describe their impact on the values you entered on your forecast sheet. Describe the impact of the temperature influences on the values.
3	Questions 3 and 9 ask about cloudiness for 18Z and 12Z respectively. Identify the resources you used to forecast cloudiness. Why was each of the resources important for forecasting cloudiness?
4	Questions 4 and 7 ask about advection for 18Z and 12Z respectively. Identify the resources you used to forecast advection. Why was each of the resources important for forecasting advection?
5	Questions 5 and 8 ask about fronts for 18Z and 12Z respectively. Identify the resources you used to forecast fronts. Why was each of the resources important for forecasting fronts?
6	What really happened? Was it different than you expected? If so, why? Describe how well your strategy worked. Has the strategy worked well for you in the past? What do you think you might have done differently with incorrect responses?
7	Are you noticing that you always lose points on the same forecast details? What do you think you might do to improve your ability to accurately forecast the temperature? Are there processes that you are having problems understanding?
8	What questions do you have?

Reflective Activity #4

Onumber	Text
1	Enter the forecast day you are using for this exercise
2	Early in the semester, I forecasted the temperature items (the actual 12z and 18z values, cloudiness, advection and fronts) in this way:
3	Now I forecast the temperature items in this way:
4	I forecast the temperature items differently now than I did before because:
5	Early in the semester, I forecasted the precipitation items (precipitation, moisture supply, fronts and stability) in this way:
6	Now I forecast the precipitation items in this way:
7	I forecast the precipitation items differently now than I did before because:
8	Early in the semester, I forecasted the wind items (speed and direction) in this way:
9	Now I forecast the wind items in this way:
10	I forecast the wind items differently now than I did before because:
11	How would you forecast for the day after tomorrow instead of forecasting for tomorrow? For example, all semester, if you sat down Monday to forecast, you have been trying to predict Tuesday's conditions. Now, if you sat down Monday to forecast and were asked to predict Wednesday's conditions instead of Tuesday's, how would your forecasting change? From a 'tomorrow' forecast to a 'day after tomorrow' forecast, speculate in detail what forecasting processes you might do differently, and what processes you would do the same.

APPENDIX D. INTERVIEW PROTOCOLS

Interview #1

1. What is your name?
2. Can you describe the process you use to write a forecast for the forecasting assignment in Meteorology 206?
3. What resources do you use for determining the effect of the various weather factors on your final forecast?
4. Do you use different resources to forecast winds and temperature? If so, which resources do you use for each, and why do you use those instead of other resources?
5. How do you forecast advection?
6. Approximately how many forecasts have you written so far?
7. Are your forecasts becoming more accurate as time goes along?
8. The instructor assigns simulations about weather phenomena prior to you learning about those phenomena in lecture. Do you think having the simulation first makes sense. Why?
9. Are there any specific things that you think could be included in the lecture to help you become a better forecaster?
10. Do you have any questions for me?

Interview #2

The purpose of the second interview was to videotape the students producing a forecast. The videotapes were created to see which resources each student used when writing their forecast. The interviewer was in the room with the student while he created the forecast. The interviewer asked two general questions and several more specific questions after the forecast was written, unless the student volunteered details about the forecast.

General Questions

1. What resource / web page were you just using?
2. Why do you use that resource / web page?

Specific Questions

What resources do you use to forecast:

1. 12Z and 18Z Temperature
2. 12Z and 18Z Temperature Influences (Cloudiness, Advection, Frontal Passage)
3. Precipitation
4. Wind Speed and Direction

Interview #3

1. Can you describe the process you used to write a forecast for the forecasting assignment in Meteorology 206 at the beginning of the course.
 - A. 12Z and 18Z Temperature
 - B. 12Z and 18Z Temperature Influences (Cloudiness, Advection, Frontal Passage)
 - C. Precipitation
 - D. Wind Speed and Direction
2. What resources did you use for determining the effect of the various weather factors on your final forecast?
3. Can you describe the process you use to write a forecast for the forecasting assignment in Meteorology 206 at the end of the course.
 - A. 12Z and 18Z Temperature
 - B. 12Z and 18Z Temperature Influences (Cloudiness, Advection, Frontal Passage)
 - C. Precipitation
 - D. Wind Speed and Direction
4. What resources do you use now for determining the effect of the various weather factors on your final forecast?

For items that have changed with regard to the resources used or the manner in which the forecast is written, the following follow-up questions were asked:

For (forecast component), you said that you used to use (identified resource) to forecast. Now, you said that you use (identified resource).

1. Why do you forecast that component differently?
2. Is there a reason for doing it that way, as opposed to the way you used to forecast it at the beginning of the semester?

To conclude the interview, the following two questions were asked to identify how closely the student was keeping track of his/her developing forecasting ability:

1. Approximately how many forecasts have you written so far?
2. If you can remember the first five forecasts you wrote, how many points did those forecasts score on average?
3. How many points have your most recent five forecasts scored on average?

APPENDIX E. ARNOLD RAW DATA

Reflective Activities

Reflective Activity #2

1. 22
2. I used the previous days temperature graph and dew point temperature graph to make predictions for the following day. I also used the satellite graphs to determine whether or not any clouds would possibly effect the following days forecast. The temperature graphs were important because they gave me an idea of what to possibly expect for tomorrow by following a trend. The Satellite graph was important to let me know whether or not clouds would inhibit radiational cooling.
3. To predict the cloudiness for the following day I used the Satellite images and the wind speed and direction graphs. The wind speed and direction graphs let me know which way the wind was blowing so it would also tell me which way the clouds might be moving. Also, the Satellite images let me know if clouds were already present at the time.
4. To predict the advection for the next day, I use the Wind direction maps and wind speed maps. The wind direction will tell me whether or not advection will be created due to where the wind is coming from.
5. I use the weather channel.com doppler graphs to decide whether or not a front is on the way. The doppler radar shows where the fronts are and where they are heading.
6. Everything went relatively fine for the forecast...there were a few things that were wrong...such as whether there would be a front and what type of front it would be...other than that my strategy worked fairly well....I think to maybe get the correct answers for the front questions ...I should pay more attention to the maps.
7. Actually yes, I always seem to lose the points on the fronts part of the forecast....as I said previously I believe all I would have to do is to pay more attention to the maps and maybe use more than a couple of them.
8. no questions at this time.

Reflective Activity #4

1. 4
2. Earlier in the semester I forecasted the Temperature Items by looking at such maps as the dewpoint temperature and the wind direction maps. Also, I looked at the current days temperatures to make a possible correlation between the current days temperatures and the next days possible temps.
3. I forecast the temperature Items the same way I did at the beginning of the semester.
4. I forecast the same way because I feel that it is a good way to forecast and it seems to serve me well.
5. Earlier in the semester I forecasted precipitation items by looking at the frontal location maps on the weather channel.com and also looking at the humidity indicator.
6. I forecast precipitation items in the same way as I did at the beginning of the semester.
7. This was a good way to get the information I needed to forecast these items ..so I stuck with it.

8. Earlier in the semester I forecasted wind items by looking at the wind speed and directional maps from Iowa State University and making educated guesses as to what it might be like the next day, also I used the weather channel.com to help me make a decision as to which way the wind was most likely to blow the next day.
9. I forecast the wind items the same way now that I did in the beginning of the semester.
10. I forecast the same way because I feel that the way I forecast has served me well over the semester.
11. I would probably forecast the same way as I would for the next day but instead I would probably adjust my inputs for what I would think would be most likely to happen according to Doppler maps, satellite images, and so on.
12. I have no questions at this time.

Interviews

Interview #1

Interviewer: when don't we start by having you tell me your name

Arnold: My name is Arnold.

Interviewer : Could you help me understand the process you use for writing weather forecasts in 206?

Arnold: Sure. When I start to forecast the weather for the assignment and the current forecast, I first usually bring up another web page and go to the Weather Channel.com and I bring up their maps. I look at their maps to see what's going on with that. I also look at the information provided by certain universities on the Weather products web page such as the satellite imagery maps. I also use the dew point temperature maps and I look at all these from the day that I'm forecasting to make predictions about the previous day. I mean the following day, excuse me. I just kind of basically go off of a trend: if it looks like it's going to do this and it might stay this way unless weather is coming ahead, or if there's a front coming up or if there are winds pulling this direction or they might change this way... So I use those maps from those places to make predictions about the following day.

Interviewer: Has your decision to use commercial Web sites like the Weather Channel tended to help you write more accurate forecasts for the next day?

Arnold: Yes. The Weather Channel actually makes it quite easy because they lay out stuff for you about what might happen. They also give you the maps and show you where things are going to move. It's kind of a step up for forecasting

Interviewer: Why, then do you use the other resources that you mentioned?

Arnold: Because the Weather Channel is based centrally. I don't know exactly where it's based, but it's not based out of the actual area where the schools' forecasts are coming from. But, if I use the Iowa State University's forecasting equipment to make forecasts, it gives me a better idea than what the Weather Channel... they give me a broad idea of what might happen the next day so I also use the schools to see what happened more in depth

Interviewer: So you start with general information?

Arnold: Yes, I start with general information from them (Weather Channel) and I use the schools' information to get a better look at what might happen in our specific area

Interviewer: when you write your forecast does Dr. Yarger want you to concentrate on forecasting for Des Moines, or can you choose to do one for Ames, or is up to you?

Arnold: We forecast for K D S M and that's usually in the Des Moines area. But, when I forecast, I usually forecast for anywhere from the Ames area to between Des Moines so that central area and our area is what I usually forecasts for. I think that'd give it a broad general base for it.

Interviewer: When you write your forecast, I believe that the forecasts are graded just on the accuracy you shown in forecasting the temperature at 12 Z and 18 Z for the day your forecasting. Are there specific issues or strategies you pay close attention to when writing your temperature forecast for 12 Z that are different for 18z? Are there differences in your mind between those two ?

Arnold: Between those two values, yes, there is some sort of difference. It's at least a six to 12 hour time period so the temperature will change between night and day due to several things cloud cover and what not. I'll start out to... I'll look at the general temperatures on the Weather Channel and see what they have. Then I'll go back and use the dew point temperature graphs and everything, wind direction graphs to see which way the winds coming in from, what the temperature was for that day and the dew point temperature was for that day. Then just kinda following on a day-by-day basis how the weather's been going, I'll make a trend prediction for it. I'll look at the maps to see if a front's coming this way, where the wind's going to be coming from. if there's a cloud cover anything like that and that will influence my decision on what to make the temperature for those days

Interviewer: Does the Weather Channel make its forecasts for noon the following day or are they predicting the high-temperature?

Arnold: They usually predict the high and low temperature for the day. They don't make specific noon temperatures or specific 6:00 a.m. temperatures. They just make high/low temperature and I kinda go for noon temperature. I kinda take a little bit less than what the high was for them and also I predict it from the previous maps from Iowa State University and areas around there.

Interviewer: I left a sheet in front of you that was the print out that you submitted for the second reflective activity... the question I want to get at is about some of the effects on temperature advection and wind speed and wind direction. How you go about predicting those features of the forecast?

Arnold: For advection I usually take a look at the wind direction . I try and see which way the wind is coming from and try and predict which way the wind will come from the next day due to fronts coming in and the way that the wind's been blowing. If there's going to be significant advection... If it's coming from the north or south or maybe sometimes from the north west or southwest or Southeast if it's coming from one of

those general directions I try and say yes there's gonna be a significant advection because it's blowing from these areas. If it's blowing from the east or west you're not going to get much movement of air mass so it's just kinda going to blow across. From what I understood in class that's how I go about making my predictions for advection.

Interviewer: Do you ever use the advection formula or calculator that they provide, or do you have another strategy?

Arnold: I usually don't. A lot of times when I make my forecasts I'm in a hurry. Sometimes I'll have time to do it, but usually I really don't. I just look at it and make prediction off of that. I'm really not too involved in advection when I think about it. I just try and make the best forecast that I can.

Interviewer: Can you give me an idea of how many forecasts you've written so far this semester?

Arnold: Quite a few in a ballpark range probably anywhere from 20 to 30 maybe. Maybe more than that.

Interviewer: Do you get the sense that your accuracy is getting better from the first forecasts you've written steadily until now ?

Arnold: It varies. The first forecast I wrote was you know, kind of cruddy, but it has gotten a heckuva lot better as I've gotten used to it and I know what to look for in trends that I look for on maps but it's still varies because sometimes I'll be in a hurry and I'll just kind of want to get the forecast done and sometimes I want to work on it more. When I have more time to work on it, then I really start to actively think about it. But on the times when I don't have time to think about it I try to make the best predictions as fast as I can. Because I don't have a lot of time to do it. They've gotten a heckuva lot better since the beginning but they still very depending on how much time I have to devote to it.

Interviewer: Do you get the sense that there are some pieces of the forecasting technique that you still need to learn from class, or are they just related to the amount time got to give to it?

Arnold: I have to say having to do with predicting whether fronts are going to be there or not. Taking more time to do that (and) probably learning a little bit more about where fronts come from and how they form, their movement and stuff like that. That would help me in my forecast or maybe using the advection formula that would probably help me more in my forecasts.

Interviewer: Have they discussed... I know there's a component of the forecast that talks about frontal activity and precipitation for the next day. Have they discussed those activities in class?

Arnold: I can't recall if we've discussed frontal activity but we've discussed precipitation and advection and stuff like that in class. We just got done with wind and wind direction and where wind comes from how wind is formed.

Interviewer: have you done some of the online activities such as MountainSim, radiationsim, and budgetsim?

Arnold: Yes. I've done those. Those helped out a little bit with forecasting. You know they let me see what would happen if you say had a wind mass that was heading toward the windward side of a mountain, as it goes up, how it comes down and they give us graphs and (it) gives us you know, they plot out all the temperatures and you can change it to your specifications - trying to make little experiment out of it - that gives you a visual sense of what would happen and that helps out. Because myself, included with a lot of other people, learn visually. So if they see this and they see how it works they'll get a better idea of how it works in forecasting.

Interviewer: in talking with Dr. Yarger, I noticed that he typically assigns activities such as the online simulations before he talks about them in class. Do you think that tends to help you understand the content better or worse than if he had given you the information first and then ask you to complete the assignment?

Arnold: I see it as a good thing because if we work on it we kind of get an idea... I mean we're kind of lost when we work on it, but as we start working on it a little bit more, we kind of get into it and see we get these patterns. Right here, I can see this... so when we go to class, we kind of have an idea of what's going on. When he starts to talk about it that way, we understand more so when he talks about it in class we're like, oh, fine. It'll click in us because we understand what happened and it'll kind of answer those questions for us in class. I think it's a good thing because he's trying to get us to learn a little bit on our own as opposed to him just giving us the information and not having us do it. It almost works better to have people learn on their own. That way, they get the information for themselves. It kind of sticks in their head a little bit more. I think it's a good thing that he does that. Sometimes we'll have an activity and work on it a little bit and he'll come and discuss it in class and it isn't quite due yet. When he discusses it in class and it gives us an even better idea so we can go back as he said and complete it before it's even due. So we can do it as many times as we want before we have to turn it in.

Interviewer: As a general summary, are there any things pertaining to the way the class is taught, the way the activities are assigned, or how you are graded that you think could be done differently so you can improve your ability to forecast or make better forecasts?

Arnold: Not that I can see of right now. He's doing a fairly good job. He and Darren Miller both together are doing really good job of teaching us how the Weather works and how to forecast it. He's kind of taking it - because he has a whole semester - he's taking it bit by bit telling us how to forecast. But at the same time were also learning on our own how to forecast because he's got those little tidbits of information all over the Web site that tell us you know what is this. He explains it to us and sometimes vague and sometimes in detail. He explains it to us before he even talks about in class. It could be weeks before, so we kind of have an idea of what it's about before we go in class and he starts talking about it. I think they do a good job of teaching and the way that they have the online experiments and activities they help out really well

in the class and with the learning and understanding how the Weather works with forecasting

Interviewer: Do you have any other comments? Things that you'd like to have included in your discussion of your procedure

Arnold: Not that I can think of. As I said before, I think they're both doing a really good job. Dr. Yarger is a very bright man and he understands exactly he's talking about. I've got previous experience with him, from meteorology 101 he was a teacher there . He does an excellent job and he's really fitted for this course

Interview #3

Interviewer: for this interview I'd like to ask you about how you used to forecast winds, advection, clouds precipitation, temperature and fronts. I'll go through and ask you about each of those for the technique that you used at the beginning of the semester. Then I'll ask you again how you do them now and then I'll ask you about some other general things about you. how did you used to forecast winds at the beginning of the semester?

Arnold: when I first started out at the beginning of the semester I really didn't know anything so I just go straight to the Weather Channel and just take it right off their just to get the grade. as I started learning stuff I... you know as we learned in class about advection through wind in the beginning and we learned about... I started using the graphs on the Iowa State network for the dew point temperatures and the wind direction and wind speed and I look at those and I tried to make ...as well as the current day's temperature... I tried to make predictions as to what I would think would happen the next day. I started actually using graphs instead of being lazy about it. throughout the semester I just use those and I suppose I started getting better in my predictions as time went on because I would see what I predicted and what would actually happen the next day and from seeing how the temperature varies I got actually a better idea of what to look for in the temperature differences and on the graph and everything so that's how I went about forecasting winds.

Interviewer: what about advection?

Arnold: advection I just had no clue what it was the beginning of the semester was not until about two maybe three or four weeks into the class that we actually learned about advection and how works. so I was just kind of making guesses at first in the beginning of the semester. Then after we learned about advection, I started... at first I started using the advection formula to try to figure out but then I just didn't bother to do it I just look to see which way the winds were coming how fast they're coming and whether or not this would affect advection. that's how I forecasted advection.

Interviewer: what about clouds?

Arnold: clouds I used the satellite. Normally I would just look at the ... again when I first started out it was just the Weather Channel to see if it is cloudy or not. Now I use the satellite photograph to see cloud cover I use wind direction maps to see which

direction the winds coming in to see if a front might be bringing in clouds like bring in a certain amount of moisture to form clouds I look at the current day's and as the semester went on I was able to predict better because I could see what could possibly happen between days so I was able toward the end of the semester I was able to get a better idea of what I was looking for

Interviewer: what about precipitation?

Arnold: Precipitation I started out at the beginning of the semester, I used Weather Channel. as for precipitation I'm not a kind of guesstimate how much precipitation would show up how lifted some graphs I looked at some satellite and infrared just to kind of get an idea of what was coming and then to I checked the humidity and the dew point temperature and based on how humid it was and whether not a front was present or coming on or there was one on its way and what kind of front it was... that's how I forecasted precipitation afterwards just kind of getting a general idea of well ...We have maybe a front here and it's bringing moisture along with it and it's already this humid outside so I'm going to say it's probably about a 40 percent chance or something. Like that you know just as a general...

Interviewer: how about temperature?

Arnold: that was actually one of the easiest ones. I started out right off the bat only a couple of days looking in the Weather Channel and then we learned how to forecast temperature right off the bat. I went to the Web sites several different websites at the Iowa State website and I used the forecast temperature for that day. I also looked to what the temperature was the day before sometimes just to get a better idea of what the trend might be coming up for the day, like if something was going on. Then also as the semester went on I could see again how it progressed and how things might work themselves out and what might possibly be plausible for the next day's temperature. so that's how I worked on that.

Interviewer: what about fronts?

Arnold: fronts? I had the toughest time doing fronts. So I normally just went to the Weather Channel and looked at the Doppler maps and look at the map they set, the animated map they had set up showing which fronts are going from where. Then as it went on I started using 500 millibar maps and 850 millibar maps to actually look at the contours and see what was coming in from where and everything like that

Interviewer: so I think the only one that I didn't hear you specifically say so about right now is clouds and I think at first you said you went to the Weather Channel?

Arnold: yes

Interviewer: what do you do now?

Arnold: For clouds I use satellite and infrared to determine whether or not I think there might be cloud cover. I also look at the current day's cloud cover and I also sometimes I'll use a little myth just kinda looking outside if it's going to be blowing in the morning, most likely it might be cloudy later on that night, and if its cloudier in the morning it

might be clear later on that night I kind of just go out there and feel the air outside and kinda look around and see well it might be cloudy the whole day.

Interviewer: so if you had to. If you could tell me what an average score was for maybe the first five forecasts that you wrote, what do you think that score would be?

Arnold: The average score out of 36... I think the average score of my first five forecasts was probably 29, 29 or 30

Interviewer: and if you had to do the same thing for the latest five forecasts you've written. what do you think that score would be?

Arnold: for the latest five forecasts probably around 34

Interviewer: OK so pretty good then.

Arnold: yeah pretty good for me

Interviewer: what made you decide to change away from the forecast technique you used at the beginning of the semester?

Arnold: it was just basically that I wanted to learn how to forecast. Any Joe Schmo can go look at the Weather Channel to get the information and stick it up there. but if I really wanted to know how to forecast for later on I'd have to pay attention in class to understand how it works and that way I could really forecast. It was really interesting what I changed because it was more interesting.

Interviewer: so not necessarily because you're getting a better score?

Arnold: in essence I did get a better score because it was interesting. but I changed more because I actually wanted to learn how more than just for score wise

Interviewer: what is your current academic major

Arnold: it's kind of in limbo right now I started out... right now officially it's meteorology. I'm changing it to history because that's what I choose to do.

Interviewer: if you don't mind me asking would you tell me why you decided to to not be a meteorology major?

Arnold: I just realized that wasn't getting into it as much as the other meteorology majors were. and so I decided to drop meteorology.

Interviewer: if you look ahead your career goals do you think that they would be a science related?

Arnold: anything could happen it's possible. my career goals right now I plan on being part of the military for some time after I get out. so it could be science related depending on what the military wants me to do

Interviewer: do you think your career plans will be meteorology related?

Arnold: has for meteorology related I would probably be able to give some help with meteorology since I understand what I'm looking at now like the maps and graphs and

I have a sense of forecasting. so if there was someone that they needed to help with forecasting than I could maybe be able to help meteorologically I can't really say.

Interviewer: have you taken other meteorology courses before 206 ?

Arnold: yes I took 101 it was a required course.

Interviewer: do you plan to take other meteorology courses?

Arnold: probably not since I'm switching majors, probably not

Interviewer: OK thanks.

APPENDIX F. BETH RAW DATA

Reflective Activities

Reflective Activity #1

1. 6
2. To forecast, I used Weatherbug. I looked at the various things like wind direction, cloud cover, and other facts to figure out what to forecast for the following day
3. none at the present

Reflective Activity #2

1. 15
2. I looked at the tomorrow am and tomorrow forecasts on the weather channel site
3. I looked on weather bug to see how cloudy it was
4. I looked at random maps on the weather prouducts page
5. I once again found graphs that showed how fronts and looked see if any were on their way
6. What happened is a little different then what i actually expected. I have no idea as to change my forecasting strategy. I plan to go to the help room at agronomy hall and consult with my friends who are also in the class.
7. I have problems understanding whether or not advection is going to change the temperature.
- 8.

Reflective Activity #3

1. 26
2. To forcast, I used the weather channel web page and the 24 hour and 12 hour forecasts
3. To answer this question, i also used the weather channel's page. I looked to see how cloudy it was going to be the next day.
4. I looked at random sources until i found a map with isobars on it. I looked to see if the isobars were parellel to the wind direction or not.
5. For this, i also used the weather channels page. I looked to see if there were in any fronts moving towards Iowa and also which ones.
6. What actually happened was not that different from what i expected. My strategy worked for me really well except for the fact about precipitation influences. I thought that if it was not going to rain, i would not have to show any influences
7. Yes, I think it still deals with the same question above that i missed
8. How do i tell what precipitation influences to pick?

Reflective Activity #4

1. 10
2. Early In the semester I only used the weather channel page to predict forecasts. For the most part I just guessed about alot of the questions on the forecast. Now I use weather bug along with the weatherchannel and also other pages off weather products such as unisys and the Iowa State University site.

3. I forecast temperature by looking at the predicted temperatures for the next day on the weather channel page, and in weather bug.
4. I do not forecast temperature items very much differently now, because I did not have that many problems with it in the first place.
5. Early in the semester, I just looked to see if it was going to rain or not. Now I know if it is going to rain I usually will have to check the frontal position and moisture supply boxes.
6. Now I know if it is going to rain I usually will have to check the frontal position and moisture supply boxes.
7. Because this way is more effective. Although sometimes I still do not get them right. I still have a better chance.
8. I looked at weatherbug and at the skews on some maps to see wind direction and speed.
9. Now, I forecast in the exact same way. I have a pretty good understanding of winds, although I still get them wrong sometimes.
10. I do not forecast them differently.
11. My forecasting would be pretty much the same. I would still use the same sources, But I would look at the fronts and see if I could tell how they were moving so that I would know. I would use the weather channel page to predict temperatures and then the "tomorrow" page in weather products for the weather channel to see where the fronts were.
12. I do not understand why sometimes I get the winds wrong. When I forecast I usually have a good grasp on what is going to happen but I am still wrong most of the time when I get the scores back.

Interviews

Interview #3

Interviewer: can you tell me how you forecasted winds at the beginning of the semester?

Beth: at the beginning of the semester I just looked at the skews on the Unisys .I forget what page that's from the look to those in saw which direction the winds were pointing and how many barbs were on it to tell how fast it was going and I used the Weather Channel too. that was pretty much how I did things.

Interviewer: how did you used to forecast advection

Beth: I didn't know. I just guessed.

Interviewer: how about clouds?

Beth: it says cloudy or not cloudy on the things so I just did that or I'd look at the... they had the national maps with the cloud coverage on it, so I'd look at those sometimes.

Interviewer: what about precipitation?

Beth: I looked at to see if it was going to rain or not that didn't know what to really do about the three boxes underneath...

Interviewer: the influences?

Beth: yes. I didn't really know what influenced it. so I kind of guessed until one of my friends told me that usually the first two always influence precipitation.

Interviewer: You said that you saw her if it was going to rain where would you go to determine that?

Beth: the Weather Channel or weather bug.

Interviewer: What about temperature? how did you used to forecast temperature ?

Beth: Oh, I used to just go to the Weather Channel or the weather bug and get the next day's forecast.

Interviewer: how about fronts?

Beth: learn and when to the Weather channel's tomorrow and tomorrow a.m. because it shows the fronts as they're coming in.

Interviewer: can you tell me how you forecast winds now at the end of the semester?

Beth: I do pretty much the same way. that's pretty bad but, it's pretty much the same. I look at the Unisys skews, just to see the direction most of all and I'm a little bit more sure because sometimes I didn't really know. I guess last semester sometimes I'd guess depending on what was the day before whatever so I guess in I don't know if.... pretty much the same.

Interviewer: what about advection?

Beth: again I went to one of my friends for help and he said that if the skews on the Unisys page are running into the lines or the lines are going across them, then there's probably going to be advection. so that's how I changed during the semester I think. I didn't know beforeI still don't know for a fact exactly but that's how I do it now.

Interviewer: how about clouds?

Beth : the same way 'cause I look at whether it's cloudy or not cloudy.

Interviewer: and that's from the Weather Channel?

Beth: yes.

Interviewer : how about precipitation?

Beth: same way the Weather Channel would tell me whether it's going to rain or not.

Interviewer: how about temperature?

Beth: same way.

Interviewer: how about fronts?

Beth: I do that the same way too.

Interviewer: if you could estimate, on average, how many points your first five forecasts scored, what would that number be?

Beth: I don't know , probably in the '20s

Interviewer: and now at the end of the semester, how many points have your last five or six forecasts scored on average?

Beth: I still score in the '20s but now I have a higher chance of doing better I guess.

Interviewer: how you figure you have a better chance?

Beth: some of them come back higher but I still get low ones so I don't know why because I'm not really a meteorologist I don't know why. sometimes I still do get them low but I do get more high ones than I did before.

Interviewer: is there anything specific that you have problems forecasting accurately?

Beth: yes the causes for precipitation sometimes I just don't know and I checked the unstable box. I usually think I know what I'm doing, I guess I don't really go back that often and say oh that's why it was different.... sometimes I get the temperature off because sometimes it's.... I don't know. there's one more advection I think I probably get that wrong sometimes too, like whether it's cold or warm. because the advection part I don't really have a problem with it but the cold and warm idea....

Interviewer: do you get the impression that the way you are doing your forecast now is more accurate than at the beginning of the semester?

Beth: yes it's a little bit more but not a lot

Interviewer: the last couple of questions are about general information. they don't really have anything to do with meteorology 206 but they're going to help when we analyze the data so.... what is your current academic major?

Beth: advertising.

Interviewer: do your career goals as the see them now have anything to do with science?

Beth: no.

Interviewer: what about meteorology?

Beth: not really

Interviewer: have you taken any other meteorology courses before 206?

Beth: no.

Interviewer: the plan on taking any more?

Beth: no.

Interviewer: is there a reason why?

Beth: I'm not very good at Sciences. I've always thought weather was interesting and stuff but this just didn't do it for me.

Interviewer: thanks.

APPENDIX G. CHRISTINE RAW DATA

Reflective Activities

Reflective Activity #1

1. 5
2. I always look at the meteogram first and usually get a general idea of the temp, the wind speed, the cloud coverage, wind direction, and so on and so forth. Then I look at the weather channel maps. I also check out the maps from Ohio I think it is. I just basically shop around. I do look for systems in the distance which I think could head our way and insofar as that I do use that method to predict.
3. I know what advection should look like on a map, but I don't know what maps are best to look at for finding possible areas of advection. Plus I'm probably usually taking a shot in the dark as to the time for the forecast. I sort of understand what 18z and 12z are but I don't necessarily know what maps to look and for what times. I also don't ever know how to answer the question following the yes/no precip. question, the one about moisture supply/front position/...? As for the amount of cloud coverage it takes to be significant. I don't really know?

Reflective Activity #2

1. 27
2. For the temperature questions I first look at the University of Wyoming Difax, DSM Meteogram. I get a good sense for what the 18z temperature could be. I also check out the NCAR-RAP forecast, I have found that those surface temperature maps are usually a little high, so I take that into consideration. I also check a better source, at least what I think is a better source, the U of Illinois temperature analysis. As well as checking those maps. I see from which direction the wind is traveling. For instance, very Northernly or very much Southernly, those usually make a difference. I forecasted the 18z temp correctly because of these methods. I was off the mark on the 12z temp because it was such a drastic change and I just missed something. The temperature influences would be like what I described as to the direction the air is coming from and also the High and Low pressure systems.
3. I use the University of Illinois radar maps that show cloudiness. It is helpful to use this source because I can compare what the forecasted fronts or different systems are and where the clouds are and get a good idea of how dense or not dense the cloud coverage is going to be. Another source I use is the DSM Meteogram because it displays cloud coverage really well as well. Plus I can see many different hours of the day and how the cloudiness has changed.
4. For the most part I use the University of Illinois wind vectors map. It shows the direction of the wind and the wind vectors therefore I could get a good idea of where there would be possible advection.
5. For forecasting fronts I used the Weather channel's maps in the forecast column. There I find both the morning and afternoon possible frontal systems. Also I used the Weather

Channel radar loops to see where there was activity. I found for both times that there were no fronts.

6. temp: I do usually have more trouble with the 12z temperature forecast evidently because it's farther off in the distance, time and actual distance-wise. So a lot of times I don't forecast that right. I usually know to go under the 18z temp. although when it's as drastic a change as it was on the 27th then my prediction gets a little more questionable.
cloudiness: My cloud coverage strategy usually works. I can usually predict the cloudiness from the DSM meteogram. I think the problem could have been that I didn't look closely at the amount. I may have looked at scattered cloudiness for some time and thought that to be more dense cloud coverage. direction of wind: I think I looked at the NW and over compensated it towards the more Northernly direction when it was actually more directly W or SW. My wind direction strategy usually works.
7. I think I have been missing problems all across the board. This forecast actually would probably be more atypical because I would say that more often times I miss points for the front, advection and precipitation influences questions. Although those are pretty hit and miss as well. I think that sometimes the weather is just more predictable than others. The times when it's moreso, I'll probably end up with more points. The times when there's more activity and things going on up in the atmosphere there's more room for error. I'm no meteorologist, but I won't deny that I'm not learning a lot from doing the forecasts.
8. I don't understand the differences between the isobars, vorticity lines, and all those other lines?

Reflective Activity #3

1. 27
2. For the 18z temperatures I use the DSM meteogram. I use that source because I have found it to be more consistently accurate than others and it's easy to interpret. For the 12Z temperature I usually just guess and that's what I did. Basically I see which way the temperature looks like it'll go. Either up or down or maybe stay the same and guess. I got the 12z temp wrong but only by one degree. As for the temperature influences. There was no cold front as I thought there might be during the 18z time. So that could have been a reason for the temperature to be a bit higher. Then a cold front came along around the 12z time so that could be a reason for the temp drop. There was cloud cover for both times and no advection for both so I'd say the major impact on the temp was the cold front.
3. For cloudiness I used the DSM meteogram as well. And another surface map from Unysis to see the predicted cloud coverages. The DSM meteogram from Wyoming usually has a good showing of cloudiness so I first go to that source. I like how the meteogram shows the progression of cloud coverage much better than maps.
4. For predicting advection I used 850mb and 500mb maps from the observation analysis section of the AMS DataExtreme site. The maps are easy to read and see exactly where the advection could be occurring.
5. I predicted the cold front to come earlier than it did on Tuesday. For forecasting fronts I usually use the Weather Channel's AM and PM models of the US. They clearly show

where the fronts should be appearing and when. For a second referral I usually check the surface analysis of the IA State Univ. link.

6. My strategy worked I think the questions that I got wrong were really not that far off. For instance, the 12z temp. I only missed that by one degree. I should have just predicted a slight bit warmer because there was a pretty big difference between 35 and 27. The temp. wasn't necessarily going to change that much. The wind speed I just didn't do enough checking on that, although i wasn't too far off that either. Then the front for the 18z time, I just forecasted the cold front that came at 12z to come earlier.
7. no i miss points on all different parts. I do still have a little bit of a hard time with the precipitation influences. I usually don't know which of the three to pick if any. Although I do get those correct a lot of the time. So it's hard to say why I don't understand. As for accurately forecasting the temp. I don't know where to look for the 12z temp so a good direction for that might be helpful.
8. I don't know where exactly to look for advection? I usually get those questions right but I still don't know which maps to check?

Reflective Activity #4

1. 10
2. I only used the DSM meteogram to figure out the temp. and cloudiness. I only used the Weather channel for front values. And I never really understood how to do advection, a lot of the time I would just guess or I would go by what the 850mb or 500mb maps said.
3. Now I search more resources for finding each item. I check the ISU site for information and also the AMS site for better examples of the possible fronts. And for advection, I consult the surface maps from different sites.
4. I don't really forecast the 18z temperature differently because I usually had that one pretty close. Although, I do a little more investigation into the 12z temp. I know it's important to see where the fronts are or the direction the air is coming from in order to see which direction the temperature is likely to go.
5. I followed the frontal position for whether there would be precip. or not. I didn't know about the moisture supply or stability. I didn't check the dew point or anything. If I thought there was going to be any precipitation I would usually only check for front as the reason for the precip.
6. I check for the dew point and still the frontal position. For stability, I don't really know what to look for other than thunderstorms.
7. Now I check more for the magnitude of the front and what is the most likely form of precipitation that could come from it. I learned that the stability has to do with thunderstorms and other systems like that, of which we really wouldn't have seen much of anyway before now, since now it's spring.
8. I only used the DSM meteogram for wind speed and direction.
9. Now I check more surface maps from different sites and actually see how the wind flowing in comparison to the isobars.
10. The meteogram I found to contradict with some of the other surface maps. So it was good to use a few sources to compare wind speed and direction. Plus it was easier to see how the wind could change if there were fronts in the area.

11. I would probably look where the Highs and Lows were and where they were likely to go. Along with that I would look for the location of fronts to the west. First I would probably forecast for Tuesday and then use that as a base for how I would forecast for the next day.
12. How do you tell if there's a possibility of advection if the pressure system (where the isobars form circles) is centered right over the area for which you're forecasting.

Interviews

Interview #1

Interviewer: to get started could you please tell me your full name?

Christine: Christine

Interviewer: the purpose of the interview today is to have you describe the process you generally use to write a forecast for meteorology 206. So you could please go ahead and describe that?

Christine: First how I go to the the weather resources web page and I usually go to the meteogram from University of Wyoming because it has a lot of the components and it's easy for me to read for some reason usually I do it late in the day and by then, it has forecasted like further into the next day and then I can see a lot of the cloud coverage and the wind direction and speed, possible temperature so I get a lot of that from there and then I usually go on to the Weather Channel maps but but just like the whole country and where the different storms are developing and fronts or anything like that and then I can't remember where I go. Uni.. Somethig with a Uni...

Interviewer: Unidex, Unifax?

Christine: yes something like that. usually get a lot of temperature I've found that it has good temperature maps and it also has a different air pressure maps and also one with wind vectors usually I'll look at that for the wind those are probably the main ones and then I'll kind of go and look at the other

Interviewer: so generally start at the class' web page or from another web page that Dr. Yorker has told you about and you'll go to the meteogram at Wyoming and you get most of the information from that and then you... what is the role of going to the Weather Channel web site?

Christine: I think for the fronts mostly. I think it displays that pretty well it has a full map of the country and then it's obvious where the fronts are and it has the morning and afternoon and you can see where even see a little bit of Canada and if things are gonna come from the north or whatever and it shows how the afternoon too, where the weather is coming from basically.

Interviewer: did you mention how you get information about cloudiness for the next day?

Christine: on the meteogram it shows basically where... I'll look and see if it's totally cloudy or clear and it shows a little map in that part

Interviewer: so the you start with the meteogram and that's the first external resource you use and that helps you to get about how many percent of your determination for temperature ?

Christine: Oh for temperature? 60 percent.

Interviewer: from the Weather Channel that gives you the rest of your determination? Or do you use other resources

Christine: and also the the other one that I said. I still can't remember what it's called....

Interviewer: maybe I'll ask you one question: do you ever used the surface maps that are available from the Iowa State section?

Christine: yes it really depends too. I kind of use different ones.

Interviewer: so you've changed the way you go about it I read the reflective write up and you seem to be fairly confident in your strategy you used to determine at least one part of the forecast. I don't remember exactly if it was the 18 Z temperature or if it was the 12 Z..

Christine: yes

Interviewer: Do you have any ideas of what you might do differently to help you get both of them right or maybe add something to your strategy to get the other one that you don't necessarily always get right?

Christine: probably looking farther west and/or looking kind of in the direction that the air is coming from whichever that direction is; usually west or more northern or southerly and just seeing the kind of systems that are developing their and if there's how much of the change there's going to be. like I think at the beginning of the semester the weather was more predictable and I was getting the 12 Z temperature right more often but lately it got probably less predictable...

Interviewer: You mentioned something that I haven't heard before how far west to you concentrate on when you're writing a temperature for the next day? Like do you look into Nebraska and South Dakota or do you look into Colorado and Wyoming as far as what's going on there to predict what's going on here for the next day? You mentioned something about looking to the West...

Christine: not very far that was just a response to what I would do differently so I don't necessarily do that I would think that that would be a reasonable way to find out

Interviewer: so beyond the Weather Channel and sometimes the surface maps and the meteogram from Wyoming do you use any other resources regularly to help write a forecast?

Christine: no not really usually I just use those. I just go to that page because it's linked and there's a whole bunch of links and I don't have a TV in my room so I don't ever really watch the news to see what they have forecast or whatever so yeah, it's mostly on the Internet and on those sites.

Interviewer: is there any particular reason why you pick the Weather Channel instead of another online Weather source like KCCI or WHO .

Christine: probably I don't know I just like the looks of their maps...

Interviewer: So nothing specific. Not that they're necessarily more accurate than anybody else?

Christine: not really well I sometimes go the NCAR and R A P maps I thought that the temperatures there were often not very accurate sometimes they're too high

Interviewer: OK good. Some the other things about the course specifically... In talking with Dr. Yarger I've noticed that he usually has students complete an out-of-class assignment before he actually discusses the process in class like for instance the BudgetSim or MountainSim or radiationsim or any of the other simulation activities that he has asked you to do. Can you tell me some of the concerns or comments you might have about that, about having people do that activity before they learn about it in lecture as opposed to doing it after he's talked about it and lecture?

Christine: I haven't really had to much problem a camp like them actually because they're kind of easy and me and a lot of the people who sit around me will say "Well, that was kind of fun to do actually." because they're just little simulations and you can kind of have fun with it compared to most and work I think it's a good way to prep for class. I kind of enjoyed them.

Interviewer: So, do you have problems? I know in the BudgetSim that they ask you did get that maximum temperature to be a certain value. And I think the MountainSim had another requirement like that you had to have a cloud form at a thousand feet. Do you have problems getting that to work? Do you get frustrated trying to do that?

Christine: it's was a just trial and error and if I get frustrated, it's because I'm trying different things

Interviewer: What is your general opinion of having the simulations before the lecture as opposed to having them after?

Christine: The simulations themselves are pretty self-explanatory and easy-to-use and I think they do help with some questions. Some are thought-provoking and a little bit harder and that's how they should be but I don't think it's really that hard to do before class.

Interviewer: Are there some comments about the class in general that you'd like to make and specifically about things that... for instance if you're not satisfied with the ability you've got to forecast the temperature correctly for the next day are there some things that you think they could address directly in lecture or with other activities that you could use to help improve your ability?

Christine: let's see I think he's covering all kinds of ...I mean there's so much that I don't know about so I don't know what we aren't covering that could help me more, but I do feel like I... there are parts of the Weather that I see now that I understand more like just walking outside and so I do feel like I've learned more about forecasting even

though I'm not a meteorologist so I don't.... I know I'm not going to get it right every time.

Interviewer: if you give me an estimate of how many forecasts you've already written for 206... Could you just give me an estimate of how many forecasts you've already written for this semester

Christine: about 30.

Interviewer: do think your ability to write an accurate forecasts has increased since the first forecast you wrote or has it sort of not gotten much better

Christine: not too much better but probably a little bit better

Interviewer: Are there items on forecasting you notice you usually get wrong or are there things that you always miss or get wrong

Christine: I can't remember I think it basically differs and that's why I can't remember It's not very consistent about what points I miss.

Interviewer: But you are fairly good forecasting temperature for the next day usually?

Christine: yeah usually

Interviewer: have any other comments you like to conclude

Christine: I don't think so

Interviewer: OK thank you.

Interview #3

Interviewer: OK why don't we start by you telling me how you used to forecast winds at the beginning of the semester.

Christine: I think the beginning of the semester I only used the meteogram from Wyoming and the station model that said the direction and the speed and I pretty much just went off of that

Interviewer: So you just took the information from the University of Wyoming meteogram? OK now how did you forecast advection?

Christine: I don't think I ever knew what advection was or how to find it

Interviewer: how did you decide what to write?

Christine: I would look at different maps I think I pretty much always put that there wouldn't be much advection one way or the other maps I just saw if it crossed the isobars or not but I didn't know exactly.

Interviewer: how about clouds

Christine: I also used the meteogram and I would look at some infrared satellites and I don't know which site that was from. Yeah, mostly the same meteogram. And the station model that showed...

Interviewer: how about precipitation?

Christine: I think I would just look at the different surface maps and mostly from the Weather Channel to see where the fronts were coming from or if there were any and what kind of precipitation was coming from that.

Interviewer: how about temperature?

Christine: I used mostly - I got most of the information from the same meteogram from Wyoming - so I think I would go a lot by that and also from the Weather Channel they have 12 hour or 24 hour temperature predictions.

Interviewer: what about fronts?

Christine: I would use the Weather Channel surface map it would show the morning and afternoon and the fronts.

Interviewer: now if you could – I'm going to go back through the same facets - could you describe how you do things now? Or how you did things for the latest assignment? How you forecast winds at the end of the semester?

Christine: I used, I think I compared more from different maps I think it's pretty easy to forecast the wind. Usually it's pretty much the same between the maps or from most of my favorite sources. I think I would just check a few and if they were the same direction then I just go with that and for the speed, I think I was using the Unisys and the AMS site and the difference surface maps.

Interviewer: what about advection?

Christine: pretty much the same surface maps as the wind and just to see where the advection is.

Interviewer: what about clouds?

Christine: I think I went with... I think I just kinda did the same as just follow along when I was doing the winds to see how much cloudiness they show over the areas and then where the front or which direction the wind's going to bring the clouds possibly... so I used to just look at the specific area and not the areas around and so that's one difference I would say... I think I remember for that one there was like most of the state was clear but then in Minnesota there was a lot more cloudiness so... I mean you could just see a drastic difference. And I used to not look at that so much I would just look at the one station model like right on Des Moines and not at any the other ones around.

Interviewer: precipitation?

Christine: probably about the same I just look at the fronts and what kind of fronts they are how big they are and look at what kind of moisture is coming with that.

Interviewer: temperature?

Christine: I don't remember which ones I used. I always looked at the D S M meteogram first and then I also look into the AMS site and I usually get a pretty good estimate from those.

Interviewer: fronts?

Christine: I think I checked the Iowa State sites for that and also the AMS and the Weather Channel. Sometimes there's a little bit of difference between those and I can kind of compare that.

Interviewer: if you could estimate what your average score was on your first handful of forecasts at the beginning of the semester, what do you think your score would be?

Christine: like maybe 22 or 24.

Interviewer: and now nearer to the end of the semester what do you think your last five or six forecasts would average point wise?

Christine: probably 28 or 30

Interviewer: do you think that there's anything specific about the technique you use now that has improved your accuracy generally or is it something specific that you pay more attention to now that gives you more points?

Christine: I would say the precipitation influences and and also the advection probably because we talked about that a little bit more in class. I learned a little bit more about what that looks like

Interviewer: Do you have the sense that the technique you use now is more accurate, or that it produces a more accurate forecast than the one used at the beginning of the semester. Or are you generally just doing the same things and paying more attention to things and getting more points because of that?

Christine: probably just paying a little more attention...

Interviewer: But you do get the sense you're writing better forecasts

Christine: yes

Interviewer: You mentioned something about how you used to forecast winds and how you forecast winds now. And it was fundamentally different and also clouds. To you help me understand what it is about the original way you forecasted winds that's different from how you do it now and why it's important that there's a difference?

Christine: I think that it's important to look at to an actual map rather than just the meteogram so I think that's what I did more at the beginning (just look at the meteogram). I think a lot of times that was fairly correct but it's also good to see it on an actual map.

Interviewer: so at the beginning to use just the meteogram just took what they had?

Christine: there's a lot of information there and I would just look at that and see all that I could see there and then put that in and go back.

Interviewer: and now you use more resources or look at them differently?

Christine: I probably look at more resources.

Interviewer: and with clouds you mentioned sort of the same thing. That you do things much differently now from when you did at the beginning of the semester. Could you describe what the differences are in your eyes and why it's important?

Christine: probably learning about... when we learned about the air masses and that probably made me look to see like there's a group of clouds here not here at or something and just to look more at a broader area instead of just the Des Moines area.

Interviewer: the last handful questions just have to do with what your academic major is now. What is that now?

Christine: speech communications education.

Interviewer: when you decide to take a meteorology 216 why did you decide to take it. instead of another science course?

Christine: I needed a physical science course and I just thought it would be useful.

Interviewer: in your future goals in speech communications deal of feeling that you could use your experiences from taking meteorology as a course or is your career not going be so related to science or meteorology?

Christine: probably not my career but I think I learned some useful things about... Dr. Yorker would really stress answering the questions we had like useful fax I didn't know. I think I'll be able to use that in life in general.

Interviewer: the plan on taking any other meteorology courses?

Christine: probably not.

Interviewer: OK

APPENDIX H. DARYL RAW DATA

Reflective Activities

Reflective Activity #2

1. 26
2. First off, I always look at the weather channel's local forecast for the next day to get some kind of idea as to what is going on. Next, I look at the 18z and 6z temperatures from the day before to get a range of values. I look mostly at the surface maps to see which way the wind is blowing and if there is any advection and how severe it is. I have found, that cloud cover does not inhibit the temperature all that much in the forecast, so I try not to have that make much of an impact.
3. The resources I use to predict cloudiness, are again the weather channel as a resource. and then I will look at the surface map to see which way the wind is blowing and if where it is blowing from has much cloud cover or not. Then I will take a glance at the satellite picture in motion to see which way the clouds are rotating. I think the best resource for forecasting cloudiness is the surface map.
4. I again use the surface map to forecast advection. That is mainly the only thing I use since it has everything on one map. The surface maps are very important in forecasting advection. I will also look at the 850 mb map to see the temperature zones and if advection will or will not occur. I find the surface map generally more helpful than the 850 mb map though.
5. The weather channel website has a great surface map that shows all the fronts in the United States very clearly and I generally use this to determine the location and type of front.
6. The temperature was about 15 degrees that day with a wind of about 10 mph from the north. A large high pressure zone filled with cold air from Canada came down and as the temperature was lowered to the dew point, saturation occurred and we got some snow. With this high pressure zone came cold air advection, but no actual front. It was a bit different than expected as far as temperatures and precipitation influences, but for the most part I was right on with my forecast. My strategy of looking at the weather channel as a guide has proved to work well along with analyzing the maps to make certain tweaks in the forecast. I might analyze the levels of the atmosphere more like 500 and 850 mb. because that is where a lot of things happen.
7. I seem to always lose points on precipitation influences. I think this is the hardest thing to forecast along with actual precipitation. If I got some more teaching or one-on-one help in this area I think my forecasts would be more complete.
8. Is there any way I can set up a conference with Dr. Yarger or Darren to analyze these forecasts more especially in the areas I listed above?

Reflective Activity #3

1. 26

2. As before, I first go to the weather channel and see what they have for the forecasted temperatures. Then, I will go to the surface map for that day and look to see if any advection will occur and how that will affect the temperature readings.
3. I see what the weather channel has for cloudiness and then I look at the satellite put into motion so I can see a distinct line of clouds that might move into my area. If there is precipitation forecasted, then I will always add clouds to my forecast.
4. First I look at the surface map of that day and I look at where the winds are blowing from. Then I look back behind my area at the temperatures and decide if they are cooler or warmer or the same as the temperatures in my area. Then, I look at the 500 mb map to see clearly if there is any advection with the jet stream.
5. Again, the weather channel's surface map forecasted for the next day is an invaluable resource from which I base my predictions off. However, I look at the upper atmosphere to decide if the jet stream is revealing a trough or a ridge and the pressure differences. This, plus the existence of fronts usually to the west, come into play in my forecast.
6. My forecasted temperatures and fronts were fairly accurate as I earned full credit for most of these portions. The only that tripped me up was the advection and the winds, I expected winds out of the SE, but found that they were out of the NW. Also, I predicted warm air advection because of my SE winds, but actually no advection occurred.
7. Advection is a difficult thing to predict because the wind changes direction constantly and with it brings increases and decreases in temperature. Also, sometimes it is not obvious whether fronts will appear or not. Just because you have rain doesn't mean that a cold or warm front is passing through. I need to understand the upper atmosphere maps better and the pressure differences to be able to predict fronts.
8. I went to the help room before the last exam and was very unimpressed with the help they gave me. I felt like I was teaching myself, I wonder if Darren could have some time in the help room so we can go at our leisure and discuss problems with him?

Reflective Activity #4

1. 10
2. Basically, I looked at the maps from the previous day and took a ballpark guess as to what the temperature would be, there was really no strategy involved in my forecasting temperature.
3. First and foremost, I look at the weather channel's forecast. Then, I go back and look at the 12z and 18z maps and factor in advection and fronts that would change the temperatures.
4. I was not getting the results that I had wanted. My temperatures were not fitting in the 10 degree category and that is a pretty large margin to have error in. However, temperatures are continually changing and so is advection and winds so I think that getting a perfect temperature is near impossible. There had to be room for error. My method of forecasting now is much more precise and usually fits in the 10 degree interval.
5. I had no clue about these at the beginning of the semester as did everyone. Basically, I looked at the surface map and if I didn't see green anywhere near the location, I didn't forecast precipitation. Stability and moisture were somewhat confusing to me, so I usually just guessed on those.

6. First I look at the surface maps to see where the fronts are located in the U.S. at that time. Then I take a peek at the satellite to see where the clouds are most dense indicating the position of a front. Then, I will look at the dew points in that region to determine if moisture plays a role in the precipitation. If there is moisture and a front nearby, instability usually follows and you get precipitation.
7. Basically as with the temperature maps, I look deeper into what I am forecasting. I don't just take a quick glance at the surface map and be done with it. There are many factors that go into play with precipitation and I have to invest more time to discover this. The result of this is more accurate prediction of moisture, fronts and instability.
8. All I did was look at the weather channel and put down whatever they had, that is simply it.
9. First I check the weather channel as a guide. Then I will look at the surface maps to see where the wind is blowing from now and how fast. Then I look at the sites all around my forecasting site and determine if the wind will stay the same or change for the next day. Fronts play a big role in this as they can change the winds drastically.
10. The winds are another thing that is very hard to forecast for. That is why usually on a weather map, they will list the winds as either calm, moderate or strong. Within these categories there are specific wind speeds, but it is difficult to tell the exact wind speed during the day. However, my method now even though it may get me the same answer as before is much more looked in to and is based mostly on the work I do and not the weather channel.
11. The pressure systems over the northern hemisphere are a good indication of what type of weather you will get over a long period of time as far as high or low pressure. I would take the information I have forecasted for the next day and look farther to the north and west at what states are seeing what weather today and tomorrow. Previous conditions for weather systems is one of the best ways to predict for your area. If it did the same thing in Nebraska, it will probably do something similar in Iowa and so on. You would have to keep a close eye on the pressure systems for fronts as they can change within hours as they die out if the moisture runs low and gain some energy if they pass over a warm, moist area like a body of water. Winds would be very hard to predict, so I would have a 10 to 15 knot range or something that people can plan on.
12. What is the "answer" to the question above? I think that some of this is right, but I would be interested to know how they do the weekly planners on the weather channel. From what I have heard from other meteorology teachers, these forecasts really have no merit in them, it is just their best guess in a sense.

Interviews

Interview #1

Interviewer: OK why don't you tell me your name

Daryl: Daryl.

Interviewer: could you please describe the process you use to write a forecast?

Daryl: I guess this kind of lays it out, but I always look at the Weather channel's forecast to begin with just to get a base of what's going on with the day and to kind of look

back on that. usually I just look at the local forecast for Des Moines. I just look at Des Moines and see what they've got. then I usually head to the surface maps that really helps me out the most I think because it gives you the most information in one map the wind speed the cloud cover it will show precipitation on there so I basically look at that from there I look at the satellite to see the cloud cover I also look at the upper atmosphere maps. the 850 millibar map helps me out of a little bit and for advection. I'm a meteorology major so I've had 111 and that talks about vorticity in there to and so I know a little bit about that. that's the basically the most of what I use is the surface map that's the one I use the most

Interviewer: why do you choose to use the Weather Channel web site

Daryl: They are pretty reliable people know that if you're going to go for Weather you go to the Weather Channel they're usually within I mean they're pretty good about what they forecast even my meteorology 111 teacher uses the Weather Channel for his weather forecasts so it's gonna be a pretty reliable source.

Interviewer: is it better or worse necessarily than some of the other commercial Web sites like KCCI or...

Daryl: actually I've only been on a couple of other ones. it's just because when most people think of weather, you go to Weather Channel and that's the reason you're there. it's not because I've looked too much into the other ones

Interviewer: how you specifically forecast the temperature for the next day? What resources do you use to base your low temperature prediction or your 12 Z or 18 z ?

Daryl: I usually look at the the day before to see what kind of range the last day was coz usually it's pretty close unless there's say like a big cold front or a warm front coming through then it's gonna be pretty similar so I look at the 12 Z or actually the 6 Z from the last day in the early morning hours and then the 18 z from the day before so I can get some kind of feel for the prior day then I make my prediction from there

Interviewer: when you go to the Weather Channel site, do they indicate what time of day the forecast is for do they give you a 12 Z

Daryl: They don't give you the Zulu times they don't give you those they just give you the actual time of day like noon or usually they give you the forecast for that during the day and then at night it is usually not the specific time ranges so you kind of have to make a little adjustment for that but like I said, it's just a base for what my forecast would be

Interviewer: do you use the dew point at all to help you decide the temperature?

Daryl: not so much but I'll look at that for precipitation like if the dew point is high and the temperatures low they can get saturation and get some cloud cover and maybe some precipitation but for the temperatures not as much

Interviewer: when you forecast advection or when you're trying to predict the influence of advection on your temperature forecast what types of resources do use for that?

Daryl: the winds are basically a big key I think along with the temperature so service maps shows me the winds were they are coming from how strong they are and the temperatures above that or below that where they're coming from you can tell if there like in the cold air or warm air advection that way

Interviewer: I've sat in on the class a couple of times and I noticed a Dr. Yarger typically has students do assignments before he's talked about some of the topics in class ...

Daryl: You mean like the MountainSim and stuff like that?

Interviewer: correct. What is your impression of that ordering of the activity before the lecture as opposed to the other way around?

Daryl: I think it helps out I mean if you do something before it gives you some kind of base to know what your going on in class if you haven't done anything before class you might not pay attention as much and you will be like what's this I don't think I should really listen but if you've gone over something before something might of tripped you up and then you listen and you say oh yeah I know how to do that now Yeah, before is better than after

Interviewer: have you noticed at all in those simulations that you had any difficulty with any specific topics that then were answered in lecture?

Daryl: Yeah, I thought that the MountainSim one was kinda like I didn't understand it there were like three or four choices you could make the leaf and the cloud cover to appear and I got kind of confused on in know where to put that, where that fit in with the whole thing that kind of cleared up when we went over it in class we actually went over the activity did it in class as a group and that it cleared it up for me.

Interviewer: another one that seemed to confuse people I guess was the budget Sim where you had the faucet and a tank full of water. Did you do that one?

Daryl: yes I did that one and it didn't really I mean at first it was like I didn't know what to do but then you kind of experiment and play around with it a little bit and I kinda figured it out it didn't pose much of a problem for me

Interviewer: You mentioned in your print out there the strategy you use where you go to the Weather Channel first and then use surface maps for most everything and that's worked pretty well for you. have you tried other strategies for writing forecast?

Daryl: other strategies you mean like looking at other different maps? Or different Weather Channel sites?

Interviewer: have you tried not going to the Weather Channel at all and just using...

Daryl: I have yet when I don't have time to wait for like the local forecast to appear but then I just jump right into the surface maps and the upper atmosphere maps those are the best resources besides the Weather Channel I'm gonna try some of those before just to see if I can do it and then check the Weather Channel's Local forecast to see what I've got after instead of before that could be something I could try but not at this point I haven't

Interviewer: are you meteorology major?

Daryl: yes

Interviewer: how many other meteorology courses have you taken besides 206?

Daryl: meteorology 101 is just the lecture course people come in and tell you what you can do with the meteorology major I'm in 111 now which is you go over forecasting and were actually doing a... we have a city that we forecast for we use the same program for forecasting as the 206 with Des Moines. only we use a different city so those two class's kind of coincide and they help me out one for the other so that's like my extent so far.

Interviewer: do you anticipate that you will get into a career that involves meteorology

Daryl: that's my hope I'm majoring in meteorology and minoring in communications maybe hopefully some day be on TV forecasting the weather

Interviewer: you want to be a weatherman?

Daryl: yes see how that works out

Interviewer: are there any specific elements of the forecast that give you trouble each time

Daryl: I think the temperatures hard to predict within I mean it gives you a range but it's hard to predict really close also I think that the precipitation you know those three influences like it's your moisture fronts I don't know what the other one is but those three influences the ones you check are the most problem for me cause when I look at those...

Interviewer: have they spoken about that in class specifically?

Daryl: They haven't really specifically gone over I'd like to see they'd go over in class like go over a forecast and specifically look at the areas that we list as trouble spots I know Darren does a good job with that but I think they need to specify certain areas instead of doing a general overview of the whole thing

Interviewer: if your comments were to be used exclusively to change the course what are some things that you would do with the way topics are outlined or presented that you think would benefit you the most to help you write more accurate forecast

Daryl: as far as the class is concerned and not just the forecast I don't think the stuff that they go over in lecture really coincides with the test I think the tests are a lot more in depth and more in detail than the actual lecture I pay attention in lecture and take notes all the time and when it comes to the test I read in the test just really messed me up and don't understand what's going on. so I think there should be more detail or that the test should coincide more with the lecture but for that portion for the forecasts I wish we could I don't know if we can be more interactive like in class like with the forecast like if we all went over it and I don't know how you can do that with so many people maybe more interaction some how I like the short answer things that we do that's good because we can get involved instead of just falling asleep all class

Interviewer: the of a general comments that you'd like to give about the overall quality of the class?

Daryl: I think it's a good class I mean I'm interested in it it's fun I think I think that I guess Darren is good I think that Darren is better sometimes than Dr. Yorker kind of is like he doesn't get the point across as well as I think he should Darren's there to kind of enforce that a little bit so I think the overall class is good and I think it will help me in the long run with my meteorology

Interviewer: do you use the out of class meteorology resources like the forecasting assistance they offer

Daryl: I'm going to start doing actually I was thinking about that I was going to see how this first test went and it didn't go as well for me as I thought so I'm gonna start heading over there and see if I can get any help

Interviewer: if yet estimate how many forecasts you've written so far in this semester how many do you think?

Daryl: I'd say maybe 10- 12 something like that I don't have the exact number

Interviewer: have you noticed an improvement in year accuracy with regard to forecasting temperature from the first forecast until now

Daryl: Oh yes. I can definitely see that I had no meteorology experience at all before I came here except for like watching the Weather Channel now and again but that's definitely improved through the class I think

Interviewer: are there certain things that you know you need to pay attention to to do well with forecasting the temperature

Daryl: I guess Darren's thing that he does every day I guess I pay more attention to what he goes over in that basically just pay more attention to the forecast with Darren I think

Interviewer: OK thanks a lot.

APPENDIX I. ED RAW DATA

Reflective Activities

Reflective Activity #1

1. 6
2. When deciding on what to forecast for my temperatures, i looked at the current surface maps, and what i thought would move into the area over the next 24 hours. I thought that the system moving in would get here faster bringing more warm air in from the south. 3) i thought that there would not be significant cloudiness at the 18Z hour. 4)i thought that the next system would be moving in quicker bringing a strong southerly flow and along w/ that warm air advection. 5)The front i thought that would be moving closer was not going to be within 140 miles. 6)i predicted 27 degrees because i knew clouds would affect it, but i also thought that there would be a warmer flow. 7) i thought that the front way off to our west would start to give iowa a southerly flow bringing in warm air 8)No front in the state yet. 9)satellite showed that if the cloudy areas held together that it would be cloudy.
3. i don't really have any questions...i was just about a day ahead on my forecast.

Reflective Activity #2

1. 27
2. I used the ETA temperature model at www.rap.ucar.edu to predict the 12z and 18z temps. By looking at the contours i estimated what it predicted the temps to be. From the 850 mb. map, there will more than likely be cold air advection in the area causing lower temps.
3. There will be a front in the area according to the surface map. I also looked at the precipitation forecast at www.rap.ucar.edu. it showed precipitation in the area just to our south, so i assumed there would be clouds here also.
4. I used the 850 mb temperature map at www.rap.ucar.edu, and 850 mb map off of ISU's page to look at the current picture. I guessed that the north winds would blow in some colder air.
5. I used the MSLP/winds map at www.rap.ucar.edu, and the surface map to judge where there may be a front at tomorrow. A cold front will be just south of us tomorrow morning. I don't know if it'll have much affect on us at 18z, but it could, so i put that it might still effect us then.
6. The only part that i messed up on the forecast was the frontal position. The reason i messed up was because i didn't take into consideration how far the front would move during the 24 hour period from when i forecasted to the forecasting period. Had i looked at the jet stream a little closer, and used more common sense, i probably would have been ok. My overall strategy has worked fair.
7. Generally when i miss points it has to do with frontal position. I just need to spend a little more time in the models.
8. I don't have any questions.

Reflective Activity #3

1. 27
2. i used www.rap.ucar.edu. the sight predicts temperatures for both 12z and 18z. i take the #'s from the map and put them in the forecast.
3. i used a recent satellite picture at rap.ucar, along with frontal position and jet stream to predict whether clouds would be present.
4. i used an 850 mb map at rap.ucar to see if it predicted any advection tomorrow. it showed that there wouldn't be much wind across the contours.
5. i used the isu sight looking at a surface map, then compared it to where rap.ucar thought the systems would be tomorrow. i don't think that the front will be here yet.
6. What i predicted for the most part happened. I messed up on wind direction, and did not pick moisture supply to favor precip. I probably just read the map wrong for the wind direction, and i did not believe that there was going to be precipitation, so i didn't look very hard for factors that would favor it.
7. My temperatures are usually fairly close to being right. When i mess up, it is either on wind or precipitation influences. If i would take more time looking at the maps, i would probably be able to be more accurate.
8. none

Reflective Activity #4

1. 10
2. using the www.rap.ucar.edu site, eta prediction map
3. same way as i started the semester
4. i don't....i learned to use this in meteor 111...to me it is the best way.
5. using the precipitaion models at www.rap.ucar.edu along with upper air temperature models
6. the same way
7. this is how i learned to do it in meteor 111.
8. by looking at surface maps on isu's page, and the predicted winds at www.rap.ucar.edu
9. same way
10. not any different
11. i would look at the eta models at www.rap.ucar.edu for further out in the period. I would also look at the current models further to the west of us than i had before.
12. none

Interviews

Interview #1

Interviewer: Why don't we start by having you say your name

Ed: Ed

Interviewer: could you help me understand the process you use to write a standard weather forecast for meteorology 206 ?

Ed: I used a bunch of model data that is a bunch of models that predict the future which a lot of the people aren't told about in class. since I'm a meteorology major I kind of know about that.

Interviewer: all right and how do you get access to that?

Ed: at RAP.UCAR.EDU they have it all posted their I use that to predict the temperatures because it looks at it by 6 hour increments which fits the requirements for the course pretty good. For winds I use that also because it forecasts that ahead too. that's pretty much where I get that the war map advection cold air advection I look at that also it's just on a different map on the 850 millibar map that's about it.

Interviewer: so most the information you get about making your Web forecast comes from the UCAR.EDU location

Ed: yes the only other thing I use alot is the Iowa State page because it has surface maps on it just to get the conditions for now like front position and such.

Interviewer: how you decide what your baseline is going to be as far as... I know Dr. Yorker has said assuming that tomorrow will be like today but with certain changes... so how do you set your baseline?

Ed: I look at maybe about a state west depending if there's a system coming in from the north or the south and it ranges south and north according to that I also usually look at that also. It kind of tells you what more likely will happen. then if you look at a map now and wonder what's going happen.

Interviewer: Do you use any other types of outside resources? You mentioned the UCarolina Web site and the surface maps here at Iowa State . Do you use any other on-line resources?

Ed: I go to the National Weather Service site sometimes and also Channel 8's just to get a better picture of what's happening

Interviewer: what's the process you use for forecasting winds specifically

Ed: first call look at the jet stream kind of to see where the system is coming from and look at surface maps to see where the high pressure and low pressure areas are and I look at RAP.UCAR because the map kind of shows the low pressures and which direction the winds are coming from and the strength also.

Interviewer: as far as predicting advection what do you do in that instance?

Ed: I look to the jet stream get and see what's coming and look at the 850 millibar map and see if the wind is blowing across the isobars and also look to see how close together the isobars are

Interviewer: do you ever used the advection calculator that Dr. Yorker spoke about in class

Ed: That's the one with the map and it kinda just...

Interviewer: Correct.

Ed: I used it for the assignment but that's it.

Interviewer: if you could estimate how many forecasts you've written so far this semester how many do you think that would be?

Ed: 10 or 12

Interviewer: You get the sense that you're doing pretty well with forecasting accurately now

Ed: yes I'm doing better now than I did when I first started.

Interviewer: have you noticed that it was a gradual improvement or is it sort of a big jump

Ed: The more time I spend on the forecast the better they are usually but yes they are getting better gradually

Interviewer: one of the other things that interest Dr. Yorker about how people explore the class is in how this simulation activities are offered before he speaks about the activity in class how do you see that? Do you think it helps to have people do something before they learn about it in lecture or you think it'd be better if they had after lecture?

Ed: I think it really depends on the person. with me, I can do either really. being a meteorology major, I kind of know about the stuff somewhat anyway so it really wouldn't make much difference if I did it before or after

Interviewer: have you noticed personally that the simulations are challenging to you?

Ed: not really I think they've been really easy. But I heard in class that there are a lot of people who are struggling or don't understand stuff.

Interviewer: how many meteorology courses have you taken?

Ed: I took the introduction last semester 111 and then this one

Interviewer: is this progression normal for a meteorology major?

Ed: I would think so.

Interviewer: maybe take 101 first ...

Ed: yes 111 is kind of a graduate student taught class which I get quite a bit out of really. it moves along almost faster than 206 does

Interviewer: and you said you're taking that class at the same time as you're taking 206 define the taking the two classes together helps you out in one more than the other or does it not help you all...

Ed: 111 what we cover in their is kind of quicker covered but you learn just as much that seems like I have it two times a week for a half-hour but it's supposed to be three times a week for an hour. but I learned just as much if not more

Interviewer: Do you get the feeling that that the 111 course might be appropriate for everybody instead of 206?

Ed: no it's definitely just a meteorology major class because they cover everything really quick and if you don't have a base for it its gonna go right over your head probably

Interviewer: other people have mentioned that they wish they had more time in class to discuss how to write more accurate forecasts so I just wondered if you also felt that way.

Ed: I don't think the course is really designed for forecasts it's designed to learn more about weather. I think it's fine the way it is

Interviewer: do have any general comments about the course

Ed: not really it seems OK

Interviewer: Do you plan to have a career in meteorology?

Ed: yes

Interviewer: what do you plan to do?

Ed: I haven't decided for sure but probably work for the National Weather Service and right forecasts it probably won't be TV related

Interviewer: Do you have any questions for me

Ed: not right now

Interviewer: all right thank you

Interview #3

Interviewer: First of I want to get some information about you generally can you go ahead and tell me what your current major is?

Ed: meteorology major

Interviewer: what is your general career goal

Ed: I've not decided for sure yet whether I'm going to graduate school but I'll probably wind up working for the National Weather service somewhere

Interviewer: OK so your career will pretty well correspond to your degree

Ed: yes

Interviewer: Way back at the beginning of the semester when you wrote your first couple of forecasts, can you remember the technique used for forecasting winds?

Ed: think I just kind of looked at a surface map and looked a little west to see what they had that day and then formed a guess

Interviewer: and for advection?

Ed: I looked at the 850 millibar map because we kind of learned that first in meteorology 111.

Interviewer: and had you taken 111 previous to taking meteorology 206 ?

Ed: no I took it with it

Interviewer: at the same time then?

Ed: yes

Interviewer: how about clouds?

Ed: clouds I just look at the satellite?

Interviewer: and precipitation?

Ed: for precipitation I look to see where it was on the map and then see if it's gonna come through this area or not.

Interviewer: and how did you forecast fronts?

Ed: kind of just looked at a surface map and then guessed what was going to be there on the first couple and then I learned to look at other maps

Interviewer: what sort of assumption did you use or strategy I guess, for forecasting the temperature?

Ed: I looked at the trends the past couple days on maps Just to see what was out west moving our way

Interviewer: and when you say trends what do you mean?

Ed: like the high and low for the past two days for us and for places west to see if it's higher or lower. it usually doesn't change that much unless something drastic happens and you can see that.

Interviewer: as far as obtaining access to these resources, how did you gain access to the resources you used? did you use a web page? or watch TV?

Ed: Web sites

Interviewer: all web sites then?

Ed: yes

Interviewer: now this will be a little easier, how you go about forecasting the winds now?

Ed: I look at the University of Carolina web page (<http://rap.ucar.edu>) and it's pretty much forecasted for you.

Interviewer: OK is there a specific resource you use?

Ed: It's called the MSLP winds map and forecasts low pressures and where they're gonna be for the next couple days

Interviewer: and what about advection?

Ed: for advection I use the 850 millibar map there to I can also look ahead and see what the models predict it's gonna be

Interviewer: so it's also from the Carolina website?

Ed: yes. I use that site quite a bit

Interviewer: so when you forecasted advection at the beginning of the semester were you using probably the same resources as now?

Ed: instead I was probably using the Iowa State one. I still look at that once in awhile

Interviewer: and clouds

Ed: for clouds I use the satellite still pretty much

Interviewer: and precipitation?

Ed: I use the University of Carolina page for that too

Interviewer: fronts?

Ed: fronts I look at the Iowa State surface map and compare it to what the MSL P winds map shows for low pressures and stuff to see where it thinks it's going to move to

Interviewer: and temperature?

Ed: Carolina.

Interviewer: OK so if you had to describe some major differences between the way you forecasted each of the separate things what those differences be?

Ed: with the newer web site I spend a little more time look at and that makes the forecast better to me

Interviewer: so spending more time?

Ed: yes the more time I spend on the models the more I do better pretty much.

Interviewer: why do you think spending more time makes you more accurate? Do you have a sense of how much better year forecasts are now as opposed to at the beginning of the semester?

Ed: I know pretty much what all the maps mean so I can look through different ones like different models to see what they think is happening or if the different models see it a little bit differently. You can kinda compare those and see what if you spend more time on it than if you go through a real quick

Interviewer: so generally you feel that your personal accuracy improves when consulting more resources or just spending more time?

Ed: more resources if I spend more time

Interviewer: OK have you ever had any opportunity to disagree with what the published models said and you were right or that you were correct to disagree with the model because you thought you understood the situation better

Ed: I varied the temperature a little bit a couple times but as for being right maybe about 50% of the time. I haven't done it too much I usually do the temperatures fairly right

Interviewer: do you have of a sense of how many points your forecasts earned you at the beginning of the semester on average

Ed: I think they're worth 36 points...

Interviewer: 36 yes.

Ed: I think I was getting around a 26 or 27.

Interviewer: and now you're getting...?

Ed: 32 or 33

Interviewer: so about six points difference there? You think that you'll be able to write the minimum number of forecasts, 25 by the end of the semester?

Ed: yes

Interviewer: have you already surpassed 25?

Ed: I'm right around 20 or so it shouldn't be any problem

Interviewer: you have what about three weeks of school left?

Ed: yes

Interviewer: You are taking meteorology 111 at the same time?

Ed: yes

Interviewer: does that pretty much cover the same topics as 206?

Ed: it almost covers more a little bit more about what the maps mean because it's a smaller group and you can kind of talk about that a little bit more?

Interviewer: can you tell me what the makeup is of the 111 class?

Ed: it's a senior course there about 20 people our only assignment is to make forecasts. I'm actually doing Dallas forecasts in that class and we went over all the stuff and that to the use almost the same page to do the forecast but it's graded a little bit different we went over the same stuff but just a little more detail about it.

Interviewer: have you ever used any of the help resources that were available?

Ed: For 206? No.

Interviewer: You never went to the help room....

Ed: no

Interviewer: never use the online help that was available on each of the forecasts?

Ed: no

Interviewer: OK thanks a lot.

APPENDIX J. FIONA RAW DATA

Reflective Activities

Reflective Activity #1a

1. 5
2. 2-9. First I assumed the temperature tomorrow would be the same as today. I checked surface maps for current temps including forecasted highs and lows. Following that I would look for fronts in the vicinity. I would also check the 700, 500, and 300mb maps for signs of advection. Also, I would look at satellite pictures and surface maps for cloud dispersal. These can influence the temp.
1. 3.

Reflective Activity #1b

1. 6
2. If I could have been better at predicting where the clouds were moving to, and that they might stay and inhibit cooling or heating, I would have been much closer to forecasting the daytime temp. I usually look at the satellite, surface, and mb maps. The the meteorogram that darren suggested in class. However, Even when considering the relative humidity, it is difficult to know when where and how long clouds will be around. I guess I will keep practicing.
3. How do you predict the movement of clouds? How do you know when they will be above certain areas? And for how long?

Reflective Activity #2

1. 26
2. First I went to the University of Wyoming page to look at the meteogram. I took down the low and high temp for today (23-36). I made sure to compare these values to the 12Z and 18Z temps on the meteogram. Then I also looked at the meteogram for wind direction and speed (N-NE; 10mph), this helps me know where the air moving into Iowa is coming from. I noted also that the cloud cover tonight would be complete. Which means radiational cooling would be decreased. Next I went to the ISU Surface Maps. The Temp. and wind map told me there would be advection because there was significant crossing of the isobars. I also verified that it was a N-NE wind, but decided that it may be a bit stronger (possibly 15mph). Since the air moving into Iowa was colder, I new this would drop the temps for tomorrow. I then looked at the US Weather with fronts and determined that the front had passed and no new ones would come during the day tomorrow. I decided the 12Z temp would be 20, considering the cold advection and cloud cover it would have to be lower than todays 23. Then I decided the 18Z temp would be 30, also due to the cold air advection and cloud cover.
3. I looked at the University of Wyoming DSM meteogram for their station plots. The later ones showed complete cloud cover. I assumed 12Z would still be cloudy. I am not sure

how to know the cloud cover for 18Z, it is so much further than 12Z, so I guessed it would still be cloudy.

4. The ISU surface maps for temperature and wind showed wind barbs crossing the isobars at a 90 degree angle. I assumed this meant there would be strong advection all day tomorrow. And since the wind was from the north, and it is colder there than here, it would be cold air advection.
5. The ISU surface maps for fronts showed a cold front south of Iowa, and since the wind was from the north, fronts move from west to east and no portion of it seemed to line up with Iowa, I said no fronts for tomorrow. I assumed it had already passed over this area. It was the only one in the vicinity.
6. The cold advection affected the temperature a lot more than I was expecting. The temp was actually 10-15 degrees colder than the previous day. It was very cloudy and I expected that, but perhaps I should have considered it affecting temperature more. The fronts were already past, just as I expected. I predicted there would be precipitation, which was correct, but I was wrong about the influential factors. I also predicted the wind speed and direction correctly.
7. Sometimes I underestimate the effect of advection, causing my temperature forecast to be wrong. If I would take the time to complete the equation we learned in class, I would have no trouble with this. I am also having trouble with the Precipitation factors and how to find them.
8. How do you know what time of day a map is from if it doesn't have the zulu time? Does not knowing the time from the map influence my accuracy? Is there an easy way to remember the time zones? What are some forecast shortcuts?

Reflective Activity #3

1. 26
2. I used the Iowa State weather map for US weather with fronts to get my initial view of the situation. I usually use the Temperature with winds and Dew Points with winds maps as well, but I was doing my forecast before these were posted so I used the contour map for temp on the University of Illinois Webpage. I took into account the wind direction that I saw on the ISU weather map and saw that there would be some cold air advection happening in the next days forecast. I check the DSM Meteogram (at the University of Wyoming link) for the temps at 12Z and 18Z as well as the wind direction and cloud cover. I noted that the temp was just under 30 right before 18Z and about 15 for the 12Z time. There were very few clouds moving into the area, so I assumed that the temp would be about the same for the next day.
3. I look first at the station plots on the ISU weather with fronts map to note current cloud conditions from their station plot. I also note the wind direction and speed. Next, I go to the summary loops of visible, infrared and satellite images to see the cloud patterns in our area. I look toward the direction of wind to see if there are clouds, and the clouds to the northwest were thin and somewhat scattered. This led me to believe that there would be little cloudiness in the next day. I had also noted on the ISU map that there was a high pressure system nearby which means there will usually be few clouds.

4. I had a difficult time compared to my usual forecast. The ISU temp with winds map was not posted yet, so I could just look at the wind barbs in relation to the contours and look for crossing. Instead I noted the wind direction and speed on the ISU weather map and look to the University of Illinois contours of temp I saw that the isotherms were running from NE to SW in our area, and since the wind was from the NW I assumed there would be advection. However, the temp gradient across Iowa was not much, so I knew the advection would be small.
5. The ISU weather with fronts map is easy to locate and always updated. I saw a stationary front located near the Rockies and knew it would not move into Iowa by tomorrow, even though fronts move from west to east and it could be headed this way. For one it is a stationary front. For two even a more mobile front would not move quite that far in one day.
6. The 18Z temp was about 36. I underestimated this value. The reason was probably that I didn't take into account the lack of clouds, which would allow for more solar heating and raise the temp. The 12Z temp was about 15. I also underestimated this value. There were clouds present, and radiational cooling was inhibited. I predicted that, but didn't correct my temp value for it. As for the other questions on the forecast, I answered the rest correctly. There were no fronts. There were significant clouds. There was cold air advection. (all at 12Z and 18Z). There was precipitation and the wind was blowing from the NE at about 15 knots.
7. I often underestimate the effects of the advection or cloud cover on the temp. I also lose points on the Precip Factors, because I am never sure if I should mark them because they do or do not play a role when I answer Yes or No. I need to have more practice. Also, using the advection formula might help with the guess work on that part.
8. Could we review when to mark the precip factors? I know how to find them, just confused about when they should/shouldn't be marked.

Reflective Activity #4

1. 9
2. First I assumed the temperature tomorrow would be the same as today. I checked surface maps for current temps including forecasted highs and lows. Following that I would look for fronts in the vicinity. I would also check the 850, 500, and 300mb maps for signs of advection. Also, I would look at satellite pictures and surface maps for cloud dispersal. These can influence the temp.
3. I still check the surface conditions (fronts, cloudiness, dew point). I know more specific things to check for now. For example, Advection is easy to spot on a surface map with isotherms and station plots. The wind direction and what air parcels are moving where is also good to look at. I check the Meteogram for today's conditions, then check to see if there is a low pressure system or a front moving through. This usually means things will be changing and where the next day's air will come from must be looked at. If there is a high in the vicinity, I assume mostly similar weather the next day, because there are few clouds, and little wind associated with the highs. Also if I see that it will be rainy, the forecasted temp is the dew point, for that time of day.

4. I have some experience with the maps, where before I was very confused. I know more from class about what influences temperature, like advection and cloudiness.
5. I would look for big clouds and fronts nearby, but I never knew for sure what I was saying had any merit. If I heard on the news that it might rain then I would do that in my forecast.
6. First I check the low temperature and the dew point for the dew point depression. next, I check for clouds moving into the area, as well as fronts. After that I check the upper level maps to see if the atmosphere is stable or not. If the dew point depression is more than 10 and there is a moisture supply, I usually forecast rain. Especially in the case of an unstable atmosphere.
7. Now, I know that a front in Nebraska today, probably means it will be here by tomorrow. I can look at winds and see what air parcels will be moving here. Also I can understand cloud patterns and upper level maps a little better.
8. I would look at today's and put that in the box, but half the time I would put the opposite direction, because I didn't understand station plots. I really wasn't even forecasting it. I was reporting it for the current conditions.
9. I still check current conditions, but now I look at the direction, see where the wind is coming from, and look for large gradients in pressure and temp. If I see a mellow or calm area supply I assume that the winds will be similar to today's. However, when a system is passing, I take into account what the changes could be as it moves through. High pressure brings few winds. Low pressure has more.
10. I had no clue before. I couldn't tell what was going on. Now I know how to read station plots and see weather patterns.
11. Forecasting for the day after tomorrow would mean you have to forecast for tomorrow first, then going off of tomorrow's forecasted conditions, you could do another tomorrow forecast for the day after. This is rather hard in Iowa, because a two day difference in weather has the possibility of drastic change. You would have to assume wind and moisture movements, and everything else. It would take a lot more practice.
12. Are we going to forecast for the day after tomorrow, because I think it would be hard.

Interviews

Interview #1

Interviewer: okay why don't we start by you telling me your name

Fiona: I'm Fiona

Interviewer: can you describe for me how you go about generating weather forecasts for meteorology 206

Fiona: after I get on ClassNet usually the first thing I do is open up all the links to all the pages I like to go to the meteogram weather site first because it's got a nice graph of what the temperature did during the day and I can look and see when it was the lowest and highest and then I kind of compare that to the 12 and 18 Z temperatures that they ask us about. so I first take that down into consideration and the Wyoming meteogram they have the winds and the direction and the station plot all kind of graphed on the same time line. how like to look at those and see if cloudiness has

changed a lot or if the direction of the wind is changed alot. Kind of get an idea of where it's at for the day. after that I'd go to the I S U service maps because they seem to be pretty uniform over different days like you can always get to them and they're always pretty clear and easy to look at. I like to check for fronts right after that to see if there's anything moving into the area I look just in to the next couple of states over on the west side of Iowa and then I also like to check the direction and windspeed again on the surface maps. I also look to the station plots and the isobars to see if there's any crossing for advection. after that I might go out to the Weather Channel and just see what they've got to say for the next couple of days and to see if there's anything on there and then I pretty much just take the cloudiness and advection and whether I found there is any fronts or not and see if how much the advection is going to change it or not. like if it drops in at a perpendicular angle with the bars and what not just kinda guesstimate on the temperature. I think that's where I'm getting some of my problems with my temperature readings I can't remember what I use when I go for my radar but it's like right by the Wyoming one on the...

Interviewer: on the links list?

Fiona: yeah

Interviewer: OK, when you get to the Wyoming media Gramm page are you able to select what station you want to forecast for? For example can you put in that you want to forecasts for Ames Iowa or does it just give you...

Fiona: well it has D S M meteogram on the link page so I assume that's the Des Moines meteogram. and I just go off that one. it's just a blank set up.

Interviewer: one of the most important things that you primarily get graded for on these forecasts is the accuracy of your temperature prediction. What are some additional factors that play into your forecast for 12 Z and 18 Z. The next day? if you could relate those I know you mentioned that you look at the previous day's high and low and a couple other things

Fiona: if it's gonna be really cloudy then I don't expect it to get really cold at night so the 12 Z temperature the next day is maybe gonna be a little warmer than it was Today because of the radiational cooling if it's really clear you can expect it to warm up more by 18z and then I also look at the advection like I said if the winds coming from the north you can assume that that is cold air advection if there's anything happening as far as advection what I don't do that I probably should do is just plug some numbers quick into the formula which I think I've said something about on my reflections is that you've got that advection formula and I never use it as I'm just usually really quick doing a forecast and I think if I took five minutes longer to do it, then I could probably be more accurate. the formula he gave us in class would probably help if I would apply that a little more because I know that there was one time I totally underestimated the effect of the advection because I didn't look at how strong the wind was going to be. the cloudiness and the advection are the biggest things but if there's a front moving past you're going to have to look at that and see what kind of temperatures are following it and how much that might affect it. I'm

guessing I probably should be thinking more about lifting air and not really sure about the low and high pressure system and how they affect temperature because you've got parcel's moving vertically and that's probably going to affect something on the surface.

Interviewer: have they talked about that in class yet?

Fiona: just recently he started talking about like just before the last exam the pressure and how it affects everything that's one of the frustrating things about forecasting he told us at the beginning just go and do it and I had no idea. it was really frustrating to just sit there and go how am I supposed to know this for the next day? I know what the wind's doing now but I don't know what it's going to be doing 24 hours from now. so that was really frustrating. and I'm getting more and more...as you go... He's right you should practice because the more you practice and the more familiar you get with things. I still sometimes don't even know what to think there's things that we haven't talked about

Interviewer: can you give me an impression of how many forecasts you've written so far?

Fiona: maybe a dozen

Interviewer: have you noticed that your ability to forecast the temperature has improved over that dozen forecasts?

Fiona: yeah. I think the one I did for this reflective activity I got the best score on it that I've gotten so far I think it was like a 30 so that's pretty good. You've got a couple that you might have missed here and there but they've been having some grading difficulty with the program so I don't know if that plays into it at all.

Interviewer: can you help me to understand how you go about forecasting of the wind direction and wind speed and if you could name some of the resources you used

Fiona: like I said I look at surface maps and I haven't gotten quite comfortable with the constant pressure maps and I'm not quite sure how... he's been talking the last few days about how to look at those. I've been trying to look at them a little bit to... mainly I just go to the ISU page and I look at their surface maps and they got a nice little map with the dew points and winds and general weather, so... I like to go with the one with temperature and winds to look for advection and I just look at the station plots to see what direction the feathered end is pointing in the circle and that's the direction the wind is going to... I like to just go and see when it was Today and see if there's anything that would significantly push it like a front or a lot of advection. normally in the last several forecasts the wind is been either North or northeast and it was Northwest once. I try to go off what today's was because I don't know what else to look at for if something is going to drastically change the direction, I can't really forecast speed it's really hard unless there's a lot of temperature change going on or a lot of lifting or something but I'm just not used to this little pressure...

Interviewer: You mentioned that you haven't covered that much in class yet sort of to wrap up, in your estimation of the class meteorology to 06 can you identify some things

about the class that you would like to have changed so the progression of topics made sense more or your ability to forecast things correctly for the next day may improve

Fiona: going to the lecture is, I don't wanna say disorganized, but it seems that we've had a hard time getting through the class material and talking about forecasting. Maybe if they just had for the first couple of weeks may be just one day a week or maybe one day every couple of weeks where you can have just one day to focus on forecasting and people can ask questions, that would be nice because the first couple weeks we didn't talk about it much and trying to do it on your own is really frustrating I do think the web based assignments have helped because there's some things like there was an advection simulation and stuff about humidity

Interviewer: did you do the mountainsim?

Fiona: yeah

Interviewer: and they have an adiabatic?

Fiona: yes I think that I've had a lot of background with this weather stuff I mean everybody learns a lot just from regular life so there's a lot of things there that you bring into the course it's kind of not tied together really well seems like we just have chunks here and there. I'm trying to be more specific for you. I think if we had some more chunks of time where you could talk about forecasting all at once Darren seems to have a hard time because he's got like 10 minutes to try and tell us everything he can and it seems like he's pushing it to the limit. if we have a little more time we could think about it a little easier. But like said I think it's something you just have to practice on. I like how he focuses the grading on actually applying our knowledge and testing has been proved over and over and over to be inefficient and ineffective. And I like the Web assignments. It would be nicer If I had a computer at home to run them. That's the only thing in getting to the computer lab. but they're nice simulations. I've had a lot of fun with them and that's cool.

Interviewer: in talking with Doug he has mentioned to me a couple of times that he usually has you do an assignment before he talks about it in class. Do you think that if you do the assignment before you come to class that it helps you understand the material better or worse than if you had the lecture before doing the assignment?

Fiona: Sometimes when going to do an assignment I don't understand why we're doing it and that's kind of confusing to me. You open up this simulation and it's giving you all kinds of instructions but you do it and then you wonder what is the point of all this then you go to class and he explains everything to you and it makes sense. for instance there was one where we had to do something about a flow rate and I was totally lost about what it was, and when we got to class I realized it had something to do with the understanding about temperature cost in a day's time like if you're putting heat in, and why it's colder and why it's not going to get as hot as it's going to be until the afternoon it just kind of lost me as to why we're doing it. but in class he explained it and it clicked. as long as you can get people to class...it'll work. I think the way it's set up is fine I suppose the annoying thing is not knowing why you're doing it while you're doing it but I think that's more effective at getting people to do the assignment

and then come to class because it's good to have people discuss it It seems simplistic at the time I think I like it the way it is.

Interviewer: do you have any final comments?

Fiona: no

Interviewer: OK thank you.

Interview #3

Interviewer: alright to get started could you tell me how you used to forecast winds at the beginning of the semester?

Fiona: pretty much it was a guess. I would look at the station plots and on one of the maps it would show winds. Half the time I didn't know which way the station plots would show the direction the wind was going. So I would take today's information and hope that it was the same tomorrow.

Interviewer: how did you used to forecast advection?

Fiona: before I knew what it was and we learned about it in class I was guessing. I had no idea what it was. After we learned about it a little bit in class I would look on the temperature map that had the wind barbs on it and see if there was any crossing but then I hoped it was significant enough. If I saw there was crossing I said there was going to be advection.

Interviewer: how did you used to forecast clouds?

Fiona: I would look on either the satellite image or radar image and look for any visible patterns. I didn't really know how the clouds would flow where they were coming, but if I knew there were a lot in the area I would assume that they were going to be there tomorrow.

Interviewer: how about precipitation

Fiona: I pretty much went by word of mouth or what I saw on the Weather on TV or maybe if I knew there was a significant system coming into the area I would say that it was going to rain.

Interviewer: how about temperature

Fiona: I would go off to day's temperature sometimes I'd look to see if there was a lot of wind . if there was cold moving into the area and if I could tell, I would mark that it might be a little colder.

Interviewer: how about fronts?

Fiona: For fronts I would just look on the surface maps and look toward the west because I knew that they flowed from West to East. If there was one that was pretty close to Iowa somewhere on this side of the Rockies I would try to guess whether it would be here tomorrow or the next day....generally a lot of assuming and guessing .

Interviewer: how do you forecast winds now at the end of the semester?

Fiona: now I know when you look at a station plot and the barbs are on one side that it's the side that the wind is coming from and I know that one barb is usually about 10 miles per hour and one and a half is 15. I know how to read the station plots a lot better so I can tell where the wind's coming from and if there's a front coming that the winds are probably going to be stronger. If there's a lot of temperature gradient then the winds are gonna increase. if there's high-pressure in the area, there's not going to be a real lot of wind. Low pressure tends to have more winds. I guess that's about it.

Interviewer: how about advection?

Fiona: for advection you can look at the gradient of temperature across the state because we're a central state it's pretty easy to assume that... you know, a temperature gradient across the state. I try to use the formula or at least use the formula in my head to see how strong the winds are, how close the isobars are and what direction the wind is blowing. Then I see whether it's a warm air mass or cold air mass coming and then you can decide if it's going to be significant or not based on the ratio that they gave us in class. I think it is two degrees every hour for a significant change.

Interviewer: how about clouds?

Fiona: cloud patterns is still a pretty difficult thing to do. I think it takes a lot of practice but I'll look at a visible spectrum or the visible image on the satellites and see, after I've taken into account where the winds are coming from. I probably should look at the upper level stuff but I was never really comfortable with that. I would see where the patterns have been for the past day and whether there were fronts moving and look for large groupings of clouds that are going to be moving into the area along with any other air masses that may be moving around.

Interviewer: how about precipitation?

Fiona: you can look at the dew point depression between the 850 millibar map and the 500 millibar map to see if there's an unstable atmosphere. I look at a difference of 25 degrees or more you can look at. I said the dew point depression is like a ten degree difference during the day... fronts if there fronts moving and you know there's a cold front it's probably going to rain sooner than if it's a warm front ... if there's a lifting mechanism like a high-pressure system or a front or something... high-pressure is not going to be precipitation, but different things.... I'd just can't remember them right now.

Interviewer: how about temperature?

Fiona: for temperature I like to go off to day's forecast and just consider in the cloudiness advection if there's going to be any advection you've got to account for that and increase or decrease your temperature. normally the temperature doesn't change a whole lot of from day-to-day so you can base your information from today's and then use those things to change it.

Interviewer: how about fronts?

Fiona: fronts you can and as I've got little more experienced from watching the weather maps over the semester and knowing how they move across the area you know how fast certain ones move and how to tell where a stationary front is forming and which ones are which. that's just basically practice

Interviewer: it sounded from your description that several of the items that you have a significantly different way of forecasting them now than you did at the beginning of the semester. why is it that you have chosen to do things differently now as opposed to the way you did them at the beginning of the semester?

Fiona: guessing wasn't very accurate. Sometimes you wouldn't see the weather or something like that and you wouldn't have any word of mouth to go from. What I've learned the class has really applied to the forecasting, but it's still a very difficult process and there are people that study it for long periods of time. Even though I think I've learned a lot about how it's done I wouldn't claim to be able to do it in the main thing is that you learn about the patterns and and you learn about what the normal happenings are some of the elements like the advection and how that affects things and I think just having more knowledge on the things has pretty much stopped me from guessing

Interviewer: Would you say you are pretty confident that if someone asked you to forecast one of these six things that you know of a specific resource to use every time?

Fiona: I think so. I think with the way the Web is designed and all the sources that are out there and with the knowledge I've learned in the course I would be able to give an educated guess, a good guess.

Interviewer: can you give me an idea of the average score you learned on the first five or six forecasts you wrote for 206 ?

Fiona: probably about 18 points to 20 points would be pretty high for most of those. I was really frustrated I would look at all this information and not know to do with it and I would just try to think what today was like and what I think might happen tomorrow and it was all assuming. I didn't do very well.

Interviewer: and what is the average score you've earned on the most recent five or six forecasts you've written?

Fiona: about 10 points or 12 points higher so I'm up by the upper 20s or 30s. I haven't gotten a perfect forecast I don't think a lot of the things I've learned have helped me to improve, I think. I've gotten a lot better over the course of the semester

Interviewer: is there anything specific about how you write your forecast that you think has made them better? For instance, are you spending more time looking at a couple of specific things or is it more of a general improvement?

Fiona: I think more of a general planning I know I've gotten better with advection, but my temperature forecasts I still have a little trouble with because I always overestimate or underestimate one or two of the elements and that always throws my forecast off. I've gotten a lot better with fronts in the cloudiness and some of the precipitation influences even though there's been some trouble with those in the program, I think I've done better with trying to identify them...I think it's a general... you know

practice and getting used to the software and all that. becoming familiar with it has helped me to improve in general.

Interviewer: You mentioned a program what program do you mean?

Fiona: ClassNet grading and stuff. They've had some difficulty with some of them not doing what they're supposed to.

Interviewer: You mean not getting an accurate grade?

Fiona: some of the times yes they've had a couple of glitches in the program but they've got most of that worked out pretty quickly

Interviewer: the last handful of questions are just general information. what is your current academic major?

Fiona: My primary major is horticulture, my secondary major is plant health and protection.

Interviewer: do you think your career goals include a focus on science related activities?

Fiona: my entire career goal is going to be based in science. everything from biology to meteorology back to physics and chemistry it's all involved with horticulture and plant health.

Interviewer: have you ever taken any other meteorology courses?

Fiona: no

Interviewer: Do you plan on taking any more meteorology courses?

Fiona: probably not.

Interviewer: Thank you

APPENDIX K. GREG RAW DATA

Reflective Activities

Reflective Activity #1

1. 5
2. To forecast temp, I usually find out what it was today and then see if anything is coming to change it (front or jet stream or something). For cloudiness, I just look at the radar and see what is to the west of us. Advection seems to be an odd thing so I just say that it won't affect anything.
3. How can I better forecast precip??

Reflective Activity #2

1. 27
2. On questions 2 and 6, I make the hypothesis that everything will be the same for tomorrow unless something different happens (wind change, front, high or low) that was different from today. I then go to the weather channel's maps and see what they have to say about wind, temp. I also try to watch the weather forecast on the news at 5 or 6.
3. For cloudiness, I just look at the radar maps and see if any clouds are projected to move in. I assume the clouds won't change anything since we still have snow on the ground and that does a fine job holding down temp. The radars are important so I can see the clouds- it's that simple.
4. I look at the temp breakdown for the forecasted day, as seen on the weather channel's sites. If there is a big change, I might further look into it. But other than that look, I just assume there won't be any advection.
5. I just watch the news and look at the weather channel's maps to see if a front will move thru. The weather channel's web site is just a terrific site.
6. Apparently it was a bit cooler on both ends of my temp forecast. Of course it was different than what I expected, as I wouldn't have put what I did if I didn't think it was going to happen! The snow cover probably played a part in it. I've always been a bit off on the temp. Maybe I need to see where the weather is coming from better and assume that is the way it will be here.
7. I seem to lose points on temperature prediction. I need to see where the weather is coming from better and assume that is the way it will be here. Advection is kind of a strange thing to me.
8. How can I be a more complete forecaster? How can I sit down and figure out the exact weather for the next day?

Reflective Activity #3

1. 27
2. I first consult the tomorrow am of the weather channel page, I then look at the tomorrow for the weather channel and notice any fronts or patterns which might deviate from the

- "norm". I then type in Des Moines into the weather channels site and look at what they say the temp will be. I also try to watch the news before I forecast to see what they say
3. I just look at the radar and see if any clouds are visual, if I see clouds moving in, I forecast clouds The radar is a great help in forecasting cloudiness- I can see easily
 4. For advection, I usually assume that there won't be any, unless there is a huge difference in the high and low or some thing like that
 5. I first consult the tomorrow am of the weather channel page, I then look at the tomorrow for the weather channel and notice any fronts or patterns which might deviate from the "norm". The two maps show essentially a time lapse
 6. The only thing I got wrong was that I was off on precipitation influences. Apparently, the front must have moved thru faster than I expected. I think my strategy worked out fine. After all, I got 34/36! I made a guess that the front wouldn't be here and was wrong.
 7. Usually, it is just a matter of me going thru the maps and making accurate forecasts, sometimes I'm right, sometimes I'm wrong.
 8. None

Reflective Activity #4

1. 10
2. By using the weather channel's temp outlook for Des Moines, I got the high and low. Cloudiness I would just look to where our weather was going to come from and see if it was cloudy or if a high or low was coming thru. Advection I just assumed that it wouldn't happen. I just looked at the weather channel's surface map to see if a front was coming thru.
3. Pretty much the same way, I just know now whether I should trust the weather channel's temps, by looking to the west and seeing if anything is coming on the map (front, air mass or something like that.).
4. I found that I am right or pretty close by using the afore mentioned procedure.
5. Going to weather channel and looking at the tomorrow am and tomorrow maps and see if anything is moving in.
6. I so it the same way.
7. There was no need to change my style because I was close enough.
8. I pretty much just guessed, or watched the news and see what they said.
9. I go to Iowa State explanation and analysis and see which direction and speed.
10. This process seems to work pretty well, as I don't lose a lot of points in this area.
11. I would look further to the west and see what was in store. I would look at the same maps, but just look further to the west. It would definately be a lot tougher and I would probably not do so well.
12. none

Interviews

Interview #1

Interviewer: OK why don't we get started by having you say your name

Greg: My name is Greg

Interviewer: can you describe the process you use to write a forecast for meteorology 206

Greg: when I get ready to do forecast it's usually between 1030 and 11 at night so I've usually watched the news or had time to see another prediction or forecast for the day so I've general idea of what tomorrow should be like so I start out by making the hypothesis that tomorrow will be exactly like today unless there are certain factors that come through and play a part in changing the Weather such as like a front or something like that.

Interviewer: OK how you go about identifying those factors that might change the Weather?

Greg: usually I'll go to a map and and it's usually just a surface map and I'll look for any fronts or high or low or I might go the radar and see if there's anything just to the west of the area 'cause I know that the Weather that we get is usually happening a day before just to the West of us.

Interviewer: so you start out with the idea that tomorrow will be just like today and so when you sit down at say 10:30 p.m. to write your forecast, what types of resources ...where do you go to get the resources you use?

Greg: I go to the Iowa State web site, classnet then log on and then I go the forecast and then I get into the forecast by using the Weather products and then I usually scroll down and I really like start out at the Weather Channel and just get a basic forecast and I like to see what they say a and then I can usually compare that to what I saw on the news or in the paper and then from there I go to the usually the Iowa State surface products and then I'll just look at those maps and then when I'm at the Weather Channel site I look like to look the other maps they got to because they do a good job

Interviewer: when you're writing a forecast do you usually forecast just for one area everyday or do they have a restriction on what areas you can forecast for?

Greg: right now since we're still pretty amateur it's not real accurate with the stuff we have to work with pretty much just us looking at the maps and make your best predictions and gases we just forecast for like a certain area which is usually just Des Moines.

Interviewer: You mentioned that you like to go the Weather Channel to get your initial idea. Is there a particular reason why you choose the Weather Channel over another commercial website?

Greg: probably just because we're not very aware of any other way I just turn the TV channel to the Weather Channel and that's usually what I base my activities on for the day

Interviewer: there are several different components of the forecast we get a temperature prediction for 12 Z & 18 Z. how you go about making the differentiation between what the temperature is going to be at noon as opposed to 6:00 p.m.?

Greg: On the ClassNet site on the forecast and then go down to the Weather Channel it has tomorrow a.m. and then you can look through there and I usually just go to the temperatures on the ... It just has an arrow that you can click down and it brings it down and you can go to different maps. and also has more p.m. and I can get pretty close with that, but it's pretty hard to forecast the exact time. It's pretty tough to do that

Interviewer: another component is to forecast the winds or the wind direction how you go about writing that part of the forecast?

Greg: usually it's pretty nice if there's a high or a low coming because I can tell just by the circulation of the winds around the high or low which way the winds should be but sometimes when there's no... there's really nothing around but you know it's gonna be windy that's pretty tough to forecast which way the direction the winds can be coming out of but doing the speeds, that can be pretty tough too. But you really have to look to see where the wind's coming from to know how fast...

Interviewer: have they ever spoken about forecasting the winds yet in class?

Greg: yes the past two times we've really gotten into it

Interviewer: do you feel more confident that you can forecast the wind speed and direction properly or accurately now?

Greg: yes I think so just by looking at how many isobars are across the state you can tell the wind speed.

Interviewer: another component is the affect of advection. Could you describe for me how you go about forecasting if there will be advection?

Greg: just based on my experience from making forecasts there's only been once or maybe twice that advection has ever occurred so usually I just say no and don't take the time to go through all the maps because it's just an equation where it ends up being a degree per hour change or something or maybe two and it usually doesn't happen so I usually just click no.

Interviewer: if you could estimate for me how many forecasts you've written so far this semester, how many do think that would be?

Greg: and think I've written 12

Interviewer: and do you get the impression that you are making more accurate forecasts now than at the beginning of the semester?

Greg: yes definitely

Interviewer: has your strategy for writing forecast changed since the first time you started writing them? Or are you just better at applying the stuff?

Greg: I'd say that as we go through topics in class that helps a lot because before it was just kind of a guessss and now I know what it is and I have a better way to find if it's going happen or not or to make first a prediction. I suppose before I was just more or less

guessing and going to one or two maps where maybe I go to three or four now, for certain things.

Interviewer: one other item that I've noticed in class is that Dr. Yorker usually assigns people to complete a simulation activity out of class before he's actually covered that topic in class. A couple of examples would be BudgetSim or radiationsim or MountainSim. That seems to be different than how other people use simulations and curious to know how you feel about the use of simulations before you've learned about it in class and do you think that helps or does it hurt

Greg: I think, I know when I get on my computer and I have to do a simulation before I've heard about the topic, it's kind of tough. I know I don't get all the points because I really don't know all about it and I haven't looked at the book or something to know more about it and some of them are kind of confusing. but it can make you think about the topic before you get to class and then when you get to class you can get it explained. that's why I did it. I guess it's all right but it kind of seems a little backwards to do something before the topic is covered in class.

Interviewer: do think that it would be more beneficial to do this simulation activities after the lecture then before or do you think that you would get a different, or have a different opinion?

Greg: I think it would be kind of or it could be easier to do them after but then again I'd be sitting in class when he starts a new topic and maybe you know I wouldn't make the connections right away. But then when I got to the computer and start doing them if they already covered the topic I think it would be a little bit faster.

Interviewer: do you have any general.... in doing some of these interviews I've heard that some people wish that certain things throughout the class were different code they could be better forecasters. Are there some issues about the class that you wish could be different so you could become a better forecaster?

Greg: it might be kind and nice to just... to see how Dr. Yorker... and Darren... see them sit down and then have them do though forecast. I mean just go through it the way they would go through it and maybe see their thinking process. That would be kind of nice.

Interviewer: is there a particular reason why you'd want to see Doug or Darren do a forecast as opposed to having someone else from class get up and do theirs

Greg: I suppose... since both of them have been doing it for so much longer maybe they have a better format or whatever that works for them and maybe if some students get involved and want to show how they do it it would just open my mind up to some different strategies. because you know my way's probably not the best.

Interviewer: Do you have any questions or final comments?

Greg: the class is tougher than I thought because it covers so much. Meteorology is such a broad topic. We don't stay on a topic too long. The tests are pretty tough because they cover so much. but I enjoy it. it's a pretty good class.

Interviewer: do you plan to have a career that involves meteorology when you're done with school?

Greg: Well I'd like to probably be a conservationist or an NRCS. Anything working with agronomy Agriculture and stuff like that. it has a lot to do with the Weather and so... and plus I like being outdoors it's nice to know what's going on and why it's happening. so I suppose I will use it quite a bit.

Interviewer: OK thank you.

Interview #3

Interviewer: can you describe for me how you used to forecast winds at the beginning of the semester?

Greg: for winds I think I would strictly go off of how was the day before. and maybe I'd watch the forecast on TV at night

Interviewer: did you typically write your forecast late in the evening

Greg: yes

Interviewer: how did you forecast for advection?

Greg: at the beginning of the semester I wasn't really sure what it was so usually I just assumed there wasn't any .

Interviewer: how about clouds?

Greg: I think I would actually go to and infrared satellite map or another satellite map particularly if there clouds to our west. and to see if they were going to move our way or not.

Interviewer: how about precipitation?

Greg: early in the semester it was during winter and usually there wasn't any so I just look for something to put in their. I'd watch the news, of course, look at the Weather Channel site to see if there's going to be any but usually there wasn't. it's not like the spring where it can rain for week and a half straight.

Interviewer: how about temperature?

Greg: early in the semester that was definitely something I got off the news

Interviewer: and how about fronts?

Greg: based on what time of year it was. it was kind of rare for a front to go through so usually just put that there wasn't

Interviewer: alright how about how you forecast winds now?

Greg: now I use maps from the website more especially the Iowa State explanation and analysis

Interviewer: Is that a surface map ?

Greg: yes. of course now I understand more about what's going to affect the wind direction and all that.

Interviewer: what about advection?

Greg: advection at least now I know how to look for it usually I just don't so usually I just assumed there isn't going to be any, unless there's a big temperature change usually I just say there won't be any...

Interviewer: and what sorts of resources did you use?

Greg: you can look at the 850 millibar maps and the 500 millibar map and if it's greater than one degree change per hour based on which way it goes up or down its warm or cold air advection.

Interviewer: and how about forecasting clouds?

Greg: I just use the satellite because it's easy to tell if there are clouds to the West and to see if there coming at us or not

Interviewer: what about precipitation?

Greg: I definitely use the fronts map on the Weather Channel web page because you can see if anything is going to come in. I don't think that it is so much that I changed my pattern but I just know what to look for now.

Interviewer: with fronts or in general?

Greg: in general but I have to say fronts specifically just for example I went out fishing this weekend and it was great. it was like 80 degrees and I was fishing. Then all the sudden I see all kinds of clouds coming in I knew that a warm front was supposed to come in. so I kind of got to see the buildup of the different kinds of clouds and then especially just out of luck we decided we should go. we're coming out and were coming around like a hill and I'd been watching the horizon and we come around and it's lightning and so we get in the car and then I'd look up and there's a lot of hail and tornadoes warnings. it was kinda neat because I understood what was going on.

Interviewer: how about precipitation?

Greg: not that I use the news any less because I'll always go check it now and all go to the Weather Channel site since it seems to be accurate.

Interviewer: what about temperature?

Greg: Sometimes I'll watch the news and get it from there but usually, I go to the Weather Channel site and get the temperature from there.

Interviewer: and lastly fronts?

Greg: Sometimes I'll see that on the Iowa State site on the temperature map I guess I've really relied heavily on the Weather Channel site it's about the best one

Interviewer: if you were to give me an estimate of how well you scored on average on the first five or six forecasts you wrote what would that average score be?

Greg: I haven't checked but especially at the beginning of the semester I think I got like a bad score . but they got better because the weather in the winter doesn't change that much. And they got better over the first for or five but I got a lot of mid-20s.

Interviewer: how about the most recent for or five? have you noticed they're getting better?

Greg: I think I noticed I gotta 35 or 34 a couple days ago and I think I got maybe one 36 so it's pretty close to perfect most of the time.

Interviewer: so what do you think your average would be?

Greg: I'd have to say maybe a 28 to 29

Interviewer: you think of their race something you can change about the way you forecast now that would help you write more accurate forecasts?

Greg: I guess I could.... it's not so much that I look at different maps but I just know what to look at.

Interviewer: what is your current major?

Greg: my major is animal ecology.

Interviewer: what is your career goal for after-school

Greg: I'd like to be a conservation person in the NRCS.

Interviewer: and do you think your future career will have any meteorology related facets?

Greg: I suppose it would help to know what's going on with the Weather especially when you're working with agriculture

Interviewer: what is the NRCS?

Greg: is the National Resources Conservation Service

Interviewer: is that a federal government agency?

Greg: yes

Interviewer: have you ever taken any meteorology courses prior to 206 ?

Greg: yes maybe of taken other meteorology course and it'll probably be one that talks about the impact of meteorology on agriculture

Interviewer: You mentioned that the way you forecasted clouds was similar to the way you used to forecast clouds. Why do you think you haven't changed your strategy much?

Greg: it's usually not a hard thing to predict especially on the radar you can see it it has the map and if it's blocking a state or whatever...

Interviewer: well I think that's it thank-you

APPENDIX L. HAROLD RAW DATA

Reflective Activities

Reflective Activity #1

1. 5
2. I looked at the dewpoint and put that value for the 12z temp. Saw cold temps in Dakotas and dropped the 18z temp a few degrees from the 37 that is was the 5th. Saw clouds from IA to west coast with only a few breaks and assumed it would be cloudy the next day, but it wasn't. Went for a cold front, but didn't get it. Iowa was between cold fronts and I thought one would be nearby the next day. I would have dug deeper into the possibility of no clouds and got a better handle on the fronts. My front was a 100 miles too far by 12z.
3. Which analysis is used to trip the front trigger? Why is advection only for the two hours before?

Reflective Activity #2

1. 26
2. -DSM Meteogram 2z T=21 Td=18. -Iowa MesoNet n Winds...Tds n of DSM in upper singles/lower 10s...slight cold adv at 2z. -NCAR sat loop Cloud edge in n IA...clouds coming from the s -> stay cloudy all night. Thinking Td will fall because of the cadv, so thinking 12zT will be 14 (9to19 -> 2z T will only have to drop 2F which should be likely). Then crosscheck with NCAR 12hrT forecast which is between 10&15. Starting with the 12zT of 14, cloudiness will keep the 18zT from being much higher than 14, and coldadv determined from TWC"midday"isobars and NCAR's 18hrT forecast should counter daytime heating. Thinking around 14(9-19 -> gut thinking it will not get to 19, but could get to 17...also gut thinking it will not get below 7 -> 7-17 is 12) then crosschecked with NCAR 18hrT forecast which was just under 20. Model persuaded me into a 15F...realized you'd need alot of cadv to get from 14 to less than 10 during the day. Canadian H moving se -> no fronts...no influence. ***** trying scoring comments to display
3. -NCAR's IR loop...shows cloud movement and general flow. Continuous cloud shield from swUS storm looked to keep clouds coming in from the south for most of the day as a result of sw flow.
4. -TWC's morning and midday sfc forecast maps -NCAR's forecasted Ts Needed TWC isobars to determine a likely wind (n at 10knots). Needed NCAR's Ts to determine a likely T gradient. Going for cadv at 12z, but the relaxed T&P gradients for 18z so going noadv.
5. -ISU USwx wfronts High over sCan plains usually move se, so no fronts tomorrow. Crosscheck this idea with TWC forecast sfc maps.
6. It stayed cloudy, and the 18z temp was only 3 degrees warmer than the 12z temp. This very little change from 12z to 18z should indicate cold advection, the 12z map indicates cold advection (according to criteria), but there was a "no" on cold advection. The strategy of starting with the 12z period seems to work. The interesting thing for me was

how the combination of my process (and gut) and the model put me right on the 18z temp.

7. I always lose points on the fronts. They are usually right on the se edge of the box. In other words they are moving slower than what I am expecting.
- 8.

Interviews

Interview #3

Interviewer: can you go ahead and describe for me how you used to forecast winds at the beginning of the semester?

Harold: the wind direction is pretty basic from the standpoint of where the highs and lows are. it works how about the time comparing where you are in comparison to where the highs and lows are. so the direction is pretty straightforward. I may be used the models more at the beginning of the semester. when you teach meteorology you kind of hesitate to go directly to the models I did use the models before I came up with the spread of isobars across Iowa, which is what I wanted the students to use.

Interviewer: so that's how you do it now? you noticed the spread in the isobars?

Harold: yes right.

Interviewer: can you describe for me what someone is supposed to look for to do that to get an idea of how? when you look at the isobars how you compute the wind speed?

Harold: if there's less than two isobars across Iowa there's less than 5 mi. per hour if you have to three isobars across Iowa is five to 10 mi. per hour, 3 to 4 isobars across would be 10 to 20. Since you get the five knot range on there, it falls in there quite often with the simple... I've got a chart that they can look at. Interviewer: how about advection?

Harold: I was thinking about this and I couldn't quite remember how I was doing it. I don't remember how I did it...

Interviewer: what don't you go ahead and describe how you do it now.

Harold: to do it now I get the wind from the process we just described then I look at a forecasted model temperature distribution and if the temperature gradient is tight enough with a strong enough wind I start checking temperature advection processes.

Interviewer: how did you used to forecast clouds?

Harold: pretty much just looking at the Skylab (skyline?)

Interviewer: OK how do you do it now?

Harold: the same way I guess both now and then I'd be using the... if those are cloudy tonight or clear

Interviewer: how about precipitation at the beginning of the semester

Harold: looking for the short waves at the beginning of the semester when it was cold... It was pretty much orientation to the surface low if you're in the right area in

comparison to the surface low you have the better chance for precipitation but in the winter things are drier. I took that into consideration for forecasting precipitation. I forecasted more knows how precipitation because I've seen that a few flakes of snow will not register as precipitation

Interviewer: OK how do you do it now?

Harold: a big part of it is orientation to the surface low and the fronts I'd look at the shore waves first the model shortwaves and then maybe see what the models are actually raining out too. I will consider what the moisture is doing and the stability now that we're in the warmer time of the year we are getting some unstable situations.

Interviewer: how about temperature at the beginning of the semester

Harold: Dr. Yarger wanted us to present it to the students as start out with what temperature we have today and then look at any thing that might change it. if conditions might change, then your temperature might change.

Interviewer: how do you do it now?

Harold: Now I use the dew point to get the 12 Z temperature and use that to get the 18 Z temperature depending on whether its cloudy or sunny.

Interviewer: what about fronts?

Harold: I guess I did use the Weather Channel forecast Analysis quite often tried to apply the typical textbook case quite often...

Interviewer: what about fronts now?

Harold: I'm holding back now on using the Weather Channel as often. I try to look at the map that the grader actually uses a little more often now

Interviewer: and do the students know about the greater?

Harold: not yet. I've hit it in class once for sure. I didn't realize it would be a good idea until later in the semester but I did finally think that it would be a good idea for them to know which map actually verifies the fronts.

Interviewer: it looks like everything except for clouds you had some minor differences between how you did things at the beginning of the semester and how you do things now. so if you could give me an indication of what an average forecast would score at the beginning of the semester, what you think your a average early forecast would have scored?

Harold: There are easy forecasting days and harder forecasting days. on the easy forecasting days I would say the scores in the early part of the semester were in the 30's and now on the easy days there are 34s. on the tough days early in the semester maybe in the range between 24 and 26 and now maybe 26 to 28 .

Interviewer: what typifies an easy forecasting day as opposed to a difficult forecasting day ?

Harold: one big thing is whether things are organized enough to follow what the textbook case would be another factor is whether you might be in between situations for

instance if the high is right over you, then it's easy there's no border it's all high there's nothing that would make you think things are going to be different. or if a nice developed low was going through, it would be it behaves in a typical situation and it's easy to forecast. it gets tough when maybe moisture is... The timing of it can be tough maybe moistures on the way but it doesn't get their buy the forecast period that you're thinking it might have been there. or maybe a front is on the way but it didn't get there yet by the time forecasted or it went by. that's when it gets tough

Interviewer: the last couple of questions are more interesting for the students the course... but what is your current academic major?

Harold: Agricultural meteorology

Interviewer: if you look ahead your career goals will they be science related?

Harold: yes.

Interviewer: how about meteorology -related?

Harold: I think so yes

Interviewer: have you taken any meteorology courses before meteorology 206 ?

Harold: yes many.

Interviewer: a lot of graduate courses or a ? just under graduate courses?

Harold: Let's see, I've had three graduate courses since I've been here.

Interviewer: do you plan on taking any more meteorology courses?

Harold: yes I think so I don't know which one I have my eye on but yes. one or two more.

Interviewer: OK thanks.

APPENDIX M. IDA RAW DATA

Reflective Activities

Reflective Activity #1

1. 5
2. I just guess at the temperature being 35 because I think the day before was around 33. I guessed at cloudiness. I don't know where to look, but I know that a low brings cloudiness and ppt. I have no idea about advection. I don't know where to look to find out. I don't understand fronts either. Do you just look at the northwest to see what's coming? I think the nighttime temperature is around the predicted low for that day. Again, I don't understand advection, or how to tell if a front is coming through.
3. My basic concerns are where to find information on advection and fronts. I understand what both of those things are, but I don't know where to go to find out more about them.

Reflective Activity #2

1. 26
2. I usually look at the weather channel's homepage and look up the forecast for Des Moines for a quick answer. I also look at the meteogram from the University of Wyoming. But, I also know that if I look at a surface map, it will give me the temperature. Also, I could look at a current surface map and look at which way the wind is blowing to see if cold or warm advection will occur and effect tomorrow's temperature.
3. When predicting cloudiness, I look at the infrared map. Also, on the surface temp map it shows the wind and if the circle is filled in, its cloudy. The infrared gives the current cloud cover, and if not much changes, it will probably continue to be cloudy.
4. I didn't understand advection until last Monday so I would just guess. But, now I would look at the surface temp map and see how many different gradients there are and multiply it by the wind speed and the direction factor to find if its significant. Wind direction could come from a meteogram, and the direction factor depends on the direction of the wind relative to the temperature gradient. Advection is significant if the temperature change is at least 1 degree over a 2 hour period.
5. I'm still unsure of how to forecast for fronts. But, I do know that highs travel clockwise and lows counterclockwise, so I look at where current highs and lows are and see where they're headed. I also look at the radar to see if anything is headed our way.
6. There was no front at 18Z, but I thought that there would be a cold front. Also, I thought that there would not be any precipitation at 12Z, but there was. I thought the precipitation influence was frontal position, but it was moisture supply. Sometimes this strategy works, sometimes it doesn't. This is very obvious, but when I take the time to look up each factor, my score improves alot. But, I usually have to guess when it comes to fronts and precipitation influences. I don't know why there was precipitation at 12Z. The meteogram never showed the temperature meet the saturation curve. I guess it was b/c of moisture supply, then.
7. I usually lose points when it comes to fronts and advection, but after Monday's lecture, I understand advection, so hopefully I won't get those wrong anymore. I'm usually pretty

accurate with the temperature, but sometimes I'm off at 12Z. I also don't know how to tell which precipitation influences to choose. I know that if humidity is 80% precipitation is likely.

8. My main question is how to tell if there are fronts, and which maps under weather products will help me find out. Thanks.

Reflective Activity #3

1. 27
2. To determine the temperatures, I went to surface maps at ISU. I looked at the temperature map and the surface map. These gave me the general current temperatures, and I went to the Weather Channel to find the predicted temperatures for 18 and 12z to be more accurate. I've never really looked at the temperature influences to determine my final temperature. Now that I think about it, it is a really obvious thing to do. Maybe I would have realized it alot sooner if those questions were before the question where I had to select my 18Z temp. However, we have discussed why those 3 factors influence temperature.
3. To forcast cloudiness I looked at the ISU surface map and looked to see if the circle was filled in on the wind bar. I also looked at the Meteogram from U of Wyoming to look for the same thing. To finalize my conclusions, I checked the Weather Channel.
4. I looked at the ISU temperature and winds map. I looked at the temperature gradient adn the wind speed. I believe there was a gradient of 15 that day, but the wind speed didn't look that significant so I put no advection.
5. Again, I looked at the ISU surface map and at the Weather Channel's surface map to see if any fronts were entering our area. These sources were important because they showed where fronts were heading.
6. The first map confirmed that it was cloudy on Wed. It was what I expected. Sometimes I go to the IR page and sometimes I forget. It is a helpful tool, though. the maps also confirmed what I put for the temperatures. also, the surface map showed the frontal movements. Sometimes its hard to know whether or not to put a front down. but in this case, it just wasn't close enough. I thought that there would be a NE wind, but there was a S wind. The only way I know how to tell is that it is CW around a high and CCW around a low. I thought that the Low would make the wind more North, but obviously I was wrong.
7. I do seem to lose alot of points on wind direction. I think I need to pay more attention to the pressure and temp gradients b/c wind moves parallel with them. I have been looking at nearby highs and lows, but I am not very accurate with that method. I also still have some trouble with precipitation influences, but it seems to be getting more accurate than initially.
8. Could you review the best way of knowing the direction of the wind? Which maps should I look at?

Reflective Activity #4

1. 9

2. I watched the weather channel on TV to get their predicted temps for the day. I assumed the hottest part of the day was noon, so I would put their predicted high as my noon temp. For cloudiness, I thought clouds always created cooler temps. I always guessed on advection and fronts.
3. For temperature I look at the Weather Channel's website for Des Moines for the 12 and 6:00 temperatures. They also show cloudiness for each hour. I doublecheck cloudiness looking at the IR map (sometimes). I also realize that cloudiness holds down the daytime temp and increases the nighttime temps. I look on the sfc temps map to find the gradient for advection. If there is a strong gradient along with strong winds, there will be advection. I look at the sfc maps for fronts.
4. I do things differently b/c I actually learned what each item meant. Also, Darren would go over each section in class and gave us which maps to look at. Knowing which maps to look at and their significance is the biggest factor concerning my forecasting abilities.
5. I just checked the weather channel to see if they thought it was going to rain. I didn't know anything about moisture supply or stability or fronts.
6. On the Weather Channel's webpage for Des Moines, they give the predicted humidity and that is what determines moisture supply. I look on the surface map for fronts and I look at the difference between the temps and 850 and 500mb for stability.
7. I know how much humidity makes moisture supply a factor b/c we were told it in class. We were taught more about fronts and exactly what the symbols meant. Darren taught us about the instability difference of 25 degrees.
8. Weather Channel, again. I would just guess at direction, but speed was almost always 5-10.
9. I look on the sfc maps at the wind barbs for the speed and direction. However, I'm still not very good at predicting directions. I also look at the U of Wyoming Meteogram
10. I was told which maps to look at.
11. I think temperature remains fairly constant from day to day, so that wouldn't be too hard. I think precipitation and its influences would be a lot more difficult b/c that changes fairly quickly. In general, I think I would need to look at the entire map of North America to look at fronts and where they were going.
12. Is there a more precise way to forecast wind direction? I know its about parallel to the isobars, but where do I look for the isobars?

Interviews

Interview #1

Interviewer: which start by telling me your name

Ida: Ida

Interviewer: and can you help me understand the process you use to create a forecast for meteorology 206 ?

Ida: First I just look on the Weather Channel Home page and click on an area code and then you can go to the next day's forecast and they have it broken down by hour and so I just look at the 6:00 and 12:00.

Interviewer: so when you go to the Weather Channel site is there a particular reason why you chose the Weather Channel over say KCCI or another online Weather site?

Ida: because it's on our syllabus from the Weather products page, Weather Channel is there.

Interviewer: Do you get a sense of how often the Weather Channel updates their forecast?

Ida: I think it says that on there when it was last updated.

Interviewer: and how far in advance do they provide those hourly breakdowns?

Ida: I don't know. I only just look at the next day.

Interviewer: so do you just go the Weather Channel and look what they've got for...

Ida: I just look at temperature and then sometimes they have all the pictures for if it's cloudy or not and so if I know it's gonna be cloudy then I can try and figure out what is making it cloudy by going to the other sites. and sometimes they have the strength of the wind but usually I go to the meteogram at the University of Wyoming for the wind and dewpoint

Interviewer: in general which other sites besides the Weather Channel and the meteogram from Wyoming do you go to?

Ida: I'm not sure I know what site it is, but it has surface maps and I'll look at the infrared cloudiness I don't know what they're under offhand

Interviewer: but they're mostly sites that you can get to directly from the Weather products page?

Ida: yes I only go from the Weather products page

Interviewer : So you have some particular strategies you use for forecasting the winds?

Ida: I usually just look on the meteogram but I don't ever know what direction the wind is I think it'll tell me or I know I can look on the surface map I just need to count the isobars to know how strong it will be but they don't really give a direction for the next day very much so I don't get that very well.

Interviewer: do most generally lose all the points for the wind direction then?

Ida: not always. You get one out of three for just putting an answer and three out of 3 if you get it right.

Interviewer: as far as the intensity of the wind , do you usually get that right?

Ida: I usually get that pretty close

Interviewer: and one other component of the forecast is when you try to forecast advection. Do you have any specific strategy you use for forecasting whether there will be advection or not?

Ida: Well I didn't and I always just guessed but then when we talked about it two Mondays ago and I haven't... I've only done to forecasts since then but now I know how to do it anyway you just look at the temperature gradient and wind speed and then like the

coefficient and depending on the direction you can figure it out. I haven't done that yet since I haven't done any forecasts since then about two weeks ago.

Interviewer: what other resources do you generally use? You've identified the things from the Weather products page and specifically the Weather Channel and the surface maps. Are there other things you use to help you write a weather forecast

Ida: I just take notes about what Darren says in class and then I just made a sheet for myself like what different tipsy said and I made a sheet breaking down the wind and the direction and stuff and what web sites to go to and just tips like that

Interviewer: the last component of the forecast is in precipitation do you generally get all the points for that?

Ida: I usually do

Interviewer: Do you have fairly good strategy on how to forecast that accurately?

Ida: usually it says on the Weather Channel if it's going to rain so I usually don't get whether or not it's going to precipitate wrong. but it's the three things that cause the precipitation...

Interviewer: the three influences

Ida: yes

Interviewer: does the Weather Channel site give you information about whether it is going to be raining at noon or 6 or is that all part of....

Ida: I don't think they usually ... I don't think they break it down by hour I think they just say the next day

Interviewer: and the effect of fronts that's another one. Do you usually have trouble with that?

Ida: yes I do I know that I guess I'm confused about highs. I know that highs give clear and sunny and that Lows... but I don't know if those are necessarily cold front or warm front usually

Interviewer: they are just starting to talk about that in class now?

Ida: yes

Interviewer: one of the things about the course that I'm interested in is and how Dr. Yorker presents the some of the activities in class after he's had you do an activity out of class so for instance you probably participated in the budgetsim activity where you have the can of water and you turn the faucet or the MountainSim activity where you try to have a cloud appear at a certain elevation. That's a little different from other classes where you would usually have simulations after lecture. Do you have a sense of, or opinion about, whether that seems to be better to have a simulation before or if it's better to have simulation after

Ida: it's better to have a before because you have some reference point to what he's talking about plus the MountainSim we went over it so much I remember what I did and what

should be and all that stuff one thing is that I think that'd be more effective to have it to the class period Before we're gonna talk about it instead of a few in advance because if we have have a half-sheet that day sometimes I don't remember what I did so now I'm just in writing down what I did so I can put it on a half-sheet.

Interviewer: so you write down what you did or what you have done during a simulation

Ida: the first one I didn't but after the have sheet I didn't remember what I did so now I've been writing it down.

Interviewer: Do you have any difficulty getting the simulation to do what you want it to? when you're using it do you get the sense that it is confusing? Like during the budgetsim activity some people indicated that they had a hard time understanding what it was about. Did you have any problems like that?

Ida: no

Interviewer: so when you got to class, how did your simulation experience effect your ability to understand the material in lecture?

Ida: I guess I maybe didn't understand totally what that one was about. I mean I understood how to get to the goal or how to keep it at the level but I didn't know why it would stay there so then the next day when he explained it why things happened I could understand it.

Interviewer: Do you know approximately how many forecasts you've completed for the class?

Ida: about 20

Interviewer: You get the sense that your ability to forecast the weather for the next day has gotten better since the first couple forecasts?

Ida: yes it is getting better but sometimes I'll just have a really bad one and they're just ones I did in a hurry.

Interviewer: Do you get the sense that if you spend more time doing forecasts you would do better?

Ida: yes

Interviewer: and what types of things to you think you spend more time on when you devote some time that you don't spend a lot of time on when you do one in a hurry. for example when you do a quick one you use a certain set of resources and when you do write a better one ..

Ida: then I look advection and wind direction and what factors cause precipitation. those are the ones that take more time so those are the ones I guess on if I'm doing one in a hurry

Interviewer:OK do you have any general comments about how you think the course is going

Ida: I really like how it's set up because it is activity based and I think...I just appreciate that he cares if we learn it or not not just I'm going to tell you what I know and you'll try

to get a grade. that it's set up so we can understand how to forecast and understand weather, not just trying to memorize information for the test since the tests are only worth six%. They're still important because there are four of them, but it's more on activities and on our actually understanding and not just memorizing information. so I appreciate that.

Interviewer: are there some things about the course that you think they could change to make it easier for you to become a better forecaster?

Ida: it has been hard forecasted in the beginning since we didn't know was going on but they know that and they set up that way so we would eventually learned and I think that's why we can take our best 23 your whatever... It's kind of a frustrating at first but I don't know what would be better because they have all helps on their but if we don't understand what the helps are talking about it's hard to get them right anyway but now we know so ...

Interviewer: Do you have any other questions and comments?

Ida: I don't think so.

Interviewer: OK thank you.

Interview #3

Interviewer: can you tell me how you used to forecast winds at the beginning of the semester?

Ida: for winds I fink I just kind of noticed what was the day before and also looked on the Weather Channel but I did not know how to do direction of the wind I just guessed.

Interviewer: did you do the speed then?

Ida: I pretty much just guessed that too, but sometimes I'd watch the Weather Channel.

Interviewer: how did you do advection?

Ida: I totally guessed at that.

Interviewer: how about clouds?

Ida: are you talking about beginning without any help because they did talk about clouds at the beginning

Interviewer: yes however you did it for the first five or six forecasts.

Ida: I kind of just did today's weather and then figured it would be close to the same.

Interviewer: precipitation?

Ida: I watched the Weather Channel or online.

Interviewer: temperature?

Ida: same thing but also looked at... I did look at surface maps I think? I'm trying to keep them separate but I yes.

Interviewer: how about fronts?

Ida: Weather Channel.

Interviewer: if you could estimate how well you used to forecast at the beginning of the semester how you think your first five or six forecasts scored?

Ida: actually I did surprisingly well and I haven't changed that much from the beginning which is bad because now I know all the stuff.... I mean there's improvement but...

Interviewer: OK what do you think an average score would have been?

Ida: probably like 24 . I'm not sure.

Interviewer: how you forecast winds now toward the end of the semester?

Ida: I look at the surface map and then I actually still don't do this great, but if I can find a map that has isobars on it I know that the wind blows parallel to the isobars, and that the wind goes counter clockwise around a low and clockwise around a high so it's just a matter of finding that map. sometimes it doesn't show up.

Interviewer: so you are basically looking for a map that shows the isobars?

Ida: yes.

Interviewer: how about advection ?

Ida: now I just look at the temperature... I just look at the surface map at the temperature and and if there's not a tight gradient then I just automatically put no advection but if there's a tighter gradient then I also look at the wind speed and .

Interviewer: what do you mean by tight gradient?

Ida: like if there...in this box (draws an imaginary box on the table) if there were a bunch of lines then that would be all of the temperature differences. I think it goes by five. so that would be a great temperature difference.

Interviewer: how about clouds now?

Ida: for clouds I look at the... I can look at the infrared satellite thing but also when I go to the Weather Channel now I click on Des Moines forecast for tomorrow it can give me the day by day or hour by hour and I look at the cloudiness at noon and at 6.

Interviewer: what about precipitation now?

Ida: on that same website it shows the humidity... 0 h, for precipitation I just watch the Weather Channel to see if it's going to rain or not but for precipitation influences. I look under the humidity on that website because of its over 85 percent I check that box.

Interviewer: which box?

Ida: for the precipitation influences I checked moisture supply. and then for the other two for the frontal position it's from the surface map, and the unstable atmosphere I look at the 850 millibars and look at the temperature there and then look at the temperature at

500 millibars and if the difference is greater than 25 then I check the unstable atmosphere box.

Interviewer: temperature?

Ida: I just go by what they say on the Weather Channel

Interviewer: how about fronts?

Ida: I look at the surface map it's on the Weather Channel site, like the different fronts I think that's the best website I've seen.

Interviewer: so if we could generalize and at the beginning of the semester out of these six things, how many of them did you not go to the Weather Channel for? I think I remember you saying that you went to the Weather Channel for almost all of them at the beginning. now I think I remember you saying maybe just temperature or fronts

Ida: I think it's a little different because for temperature I was just looking at there specific number and that's what I would put but for fronts I actually had to look at the map. let's see and I don't go there for advection... what you want to know now or the beginning?

Interviewer: now at the end of the semester what things you go to the Weather Channel 4 I think I remember you saying temperature and fronts.

Ida: and winds I just do that out of convenience. I mean I know how to look at the surface map to see the wind I just do it because its faster.

Interviewer: OK at the beginning you said an average forecast would've been 24 or so. now at the end of the semester, how well do think you scored on the last five or six forecasts?

Ida: I think that it would be probably like 29 or 28 .

Interviewer: so it's a little bit better?

Ida: it's a little bit better but not great.

Interviewer: is there anything in your consciously aware of that you have changed in your forecasting technique?

Ida: I definitely look stuff up and I know what to look for and I spend more time on it.

Interviewer: Do you have a sense that understanding the resources that are available to you has made your forecast more accurate?

Ida: definitely because we had all those maps in the beginning but I did know what to click on or how to find it. now I have a sheet I wrote down that says what to go to.

Interviewer: have you ever written a forecast that got a 36 out of 36?

Ida: no.

Interviewer: is there anything about your technique that you think you could change now that would make your forecasts even more accurate?

Ida: I think if I understood fronts better because we're , I look on the surface map and what time is going to come through I can see what fronts are out there but I dunno where they'll be at 12 Z 18 z and I think if I knew how to do that it would help me and also with the whole wind direction I just found a map that I could use the last two times I forecast I think I'll get the direction right now.

Interviewer: what is your current academic major/

Ida: Liberal Studies and to be secondary education.

Interviewer: do your future career goals include a focus on science?

Ida: yes.

Interviewer: do you think it'll be a meteorology related?

Ida: not specifically I want to be a middle school science teacher hopefully I'll be talking about whether but I don't want to be a meteorologist.

Interviewer: have you taken any meteorology courses previous to 206 ?

Ida: no.

Interviewer: do you plan to take any more meteorology courses?

Ida: no.

Interviewer: OK thank you.

APPENDIX N. JANE RAW DATA

Reflective Activities

Reflective Activity #2

1. 27
2. I consider the previous days temperature. I look for warm and cold fronts, and cloud cover. The Weather Channel site is very helpful to consult. They are because they show fronts, and clouds. If there are significant clouds, or winds moving fronts, those affect the values for the predicted temperatures.
3. I like to look at maps that chart dew point temperatures. This is important for forecasting because when air cools to the dew point, cloud formation and precipitation are prevalent.
4. Advection still confuses me. Normally I look toward clouds and the previous day's temperature, and I make a guess from there.
5. The Weather Channel maps are great for viewing fronts. They site offers the location and potential movement of the fronts as well as the location of the highs and the lows.
6. My strategy fails to take into account atmospheric conditions that might affect precipitation. My strategy needs improvement because it has only worked moderately in the past. I might have looked longer at maps to catch things about the weather that escaped my notice the first time around.
7. Yes, I always loose points on the atmosphere conditions. I should consider the previous day's temperature more than I do in order to predict the next day's temperature more accurately.
8. Can appointments be made to get some one-on-one time for additional help with forecasting. I get so frustrated, that I give up. I don't want to miss learning this, but I'm out of hope of ever improving.

Reflective Activity #4

1. 10
2. Early in the semester, I had no idea what I was doing, and half of the time, no idea what the links I went to were showing me. I would go to many sites trying to make sense out of the whole thing. I knew 12z and 18z were important, so anything marked with those I clicked on. Advection didn't make sense to me then, and cloudiness was vague. What makes something cloudy? How does a map show it exactly? However, fronts were familiar, from watching the forecasts on the nightly news. Finally, I would make the best conclusions that I could and submit the results.
3. Now, I refer to the Weather Channel maps, as well as Iowa State University's maps. Those maps are the most clear for my understanding. I have a piece of paper next to me and I take notes over what each map shows me. (that way I don't have to keep clicking back and forth between maps.) After viewing the Weather Channel's "Tomorrow a.m" and "Tomorrow-midday" maps, I refer to ISU's maps. I make notes on all four of those, and make my forecast by refering to my notes. These maps are excellent because they show me dew point, wind direction, wind speed, cloud coverage, temperature fronts, and isobars.

4. I actually know where to go to get helpful maps, and I understand what the symbols on the maps mean, and also, what their effects are on the next day's weather.
5. I didn't even consider stability in the beginning of the semester. Moisture supply was vague, for the first couple weeks, and after that, I looked to the dew point temperature. I knew that low fronts usually meant adverse weather but being able to read the maps and actually connect the signs of precipitation was just beyond my ability then.
6. I look to the dew point temperatures, I look toward cloud coverage and the presence of a cold front, particularly backed by a low pressure system.
7. I understand, from the various cloud formation exercises, and also the lectures covering precipitation and cloud formation, why precipitation occurs when and where it does. At the end of my friends' e-mails he quotes, "With all thy getting, get understanding" and that is precisely why I can predict precipitation now.
8. One word, isobars. If they were close together it meant gusty winds, and if they were further apart it meant calmer winds. Winds always blew from west to east, unless the position of a front on the Weather Channel's "midday" map (compared to the "a.m." map) suggested to me that the wind was blowing any other way. After the lecture about knots, and the symbols used to denote wind speed, I was a much better wind forecaster.
9. I go to ISU's "Temperature and Wind" map as well as their "Dew Point and Wind" map. These maps serve a dual purpose obviously, (that is helpful) and I look at both maps for wind, though it doesn't usually change much, because I feel I'm double-checking myself, as well as increasing my forecasting accuracy.
10. I found the ISU link, and I really like it. The maps are clear for me to interpret, and provide helpful information. They provide more specific information that I wasn't getting by just using The Weather Channel's links.
11. My forecasting wouldn't change as far as the "format" I use. By "format" I mean the sites I visit, and the order in which I visit them. My format would stay the same. My forecasting would change because I'd have to figure in how much things will shift during the additional day. Specifically, I'd have to estimate how much further fronts would move in that time, among many other factors like: cloud coverage shifting, isobar movement, as well as, wind speed and wind direction change-all of these effect precipitation too. In short, I would have to visualize how my prediction for the next day would affect the day after that, and how the weather would continue to move and change into that next day.
12. Is the Bermuda Triangle a weather phenomenon as well as a mythical mystery??

Interviews

Interview #3

Interviewer: and can you tell me how you forecasted winds at the beginning of the semester?

Jane: I would just go to the Weather Channel and glance at the map and see if I could figure out from there because the fronts on the map would change from the a.m. to the p.m. and by their shifts I would guess where the wind was.

Interviewer: Is there anything else you looked at specifically for winds?

Jane: and the beginning I didn't really know what... the computer side is set up so there are a bunch of sites that you can click to. A massive amount of sites I would just click on a bunch of things and get lost and then I'd wander back and forth. So after not knowing exactly where to go I just depended on the Weather Channel. And my little guessing system.

Interviewer: can you describe your guessing system for me?

Jane: I'd look at the fronts as they move from a and to p.m. and I would guess where the wind was in which direction it was blowing.

Interviewer: how did you forecast advection?

Jane: I didn't even know what advection was at the beginning of the semester even after the first lecture, I understood what it was but I didn't recognize the signs of when it was happening.

Interviewer: and so when you had to fill in that little blank how did you make the decision?

Jane: I just guessed.

Interviewer: when you forecasted clouds what did you do at the beginning of the semester?

Jane: I learned that there's a symbol. I don't know what the symbol's called but it's a circle and from that line that shows the wind direction. So before then I would just if there's a low front near Iowa it meant clouds, and if there was a hi front that meant no clouds. That's when I did before I learned about that symbol.

Interviewer: when you talk about the symbol is that on the meteogram page or where did you see the symbol?

Jane: I would usually go to the... that comes later though. In the beginning I didn't really know.

Interviewer: what about precipitation at the beginning of the semester?

Jane: if there was a low it meant rain, if there is a high it meant no rain.

Interviewer: what about temperature?

Jane: I did know there was a temperature map and so I would go there. It would show lines across isobars or what not across the map and it would show values for each line too and whatever line Iowa fell under... 40, 45, 70, 75 I would range it.

Interviewer: and what about fronts?

Jane: fronts were easy, they were on the Weather Channel site.

Interviewer: so you pretty much went to the Weather Channel site

Jane: yes I was pretty much addicted to the Weather Channel site at the beginning of the semester

Interviewer: if you had to average or give me an average of how well you scored at the beginning of the semester on the first handful of forecasts, what do you think the point value score was, on average?

Jane: I'd say 26 to 30.

Interviewer: Alright now, can you tell me how you go about forecasting winds now nearer the end of the semester.

Jane: Near the end of the semester Darren would always give us talks and show us good sites to click to. When I went home I would try to find those sites Darren mentioned and sometimes I'd find them and sometimes I wouldn't. But in my clicking, I'd come across other things that were helpful but in the end I've adapted to things the Weather Channel of course it's the foundation and then Iowa State's home page has four items that I can go to the temperature and winds dewpoint and the ISU mesonet. And then surface temperature. I really like those they give me more information than any the other sites the Weather Channel is just the United States with fronts drawn on it may be some light rain showing on it. But on the other sites it gives me more detail, more specifics.

Interviewer: specifically for winds what you use for resources?

Jane: the Iowa State explanation and analysis site

Interviewer: so it's like a surface map?

Jane: yes

Interviewer: what about for advection now at the end of the semester?

Jane: advection I still haven't found a map that will show me advection so when it comes to advection I just talked to my friends my friend Chase and my friend Ray they're also in meteorology and they've explained advection to me. They say like when the winds cross the isobars it shows heat or cold advection or warm advection. And I also go by if a front has passed Iowa I'm guessing that the cold air if it's a cold front will be behind the front. So if a front has just passed I'm sure we will be affected by cold air advection.

Interviewer: what about clouds?

Jane: clouds I go... sometimes I click on the satellite image and that shows clouds yes or no, and sometimes I use the satellite image. But like I said earlier about the circular symbol I go to the ISU mesonet, it shows all the counties of Iowa and their temperature and dewpoint as well as the little symbol. And if there's...it's a split into quarters. If only one fourth is shaded then it's one-fourth cloudy it if it's a have shaded half the sky is covered, etc. etc.

Interviewer: is that also the same symbol that has the little arrow head? Or rather the back end of an arrow?

Jane: yes it looks like an arrow with a circular tip it indicates wind direction

Interviewer: and what about precipitation at the end of the semester?

Jane: the Weather Channel does have the it will have green for light rain that is one of the marking that I first notice and then I go to dewpoints on the I S U explanation and analysis page and I'll see that it if the dew point is really close to the temperature

that's a good indication that rain could happen because there's a significant moisture supply and also if there's a lot of cloud coverage that's also on the map I can also tell that the clouds and the moisture supply that there's a good chance that it's going to rain and if there are fronts around...

Interviewer: what about temperature?

Jane: temperatures on the temperature map, it's pretty straightforward.

Interviewer: what about fronts?

Jane: Fronts are on the Weather Channel. Pretty straight forward again there too.

Interviewer: just like at the beginning of the semester you said that you got between 26 and 30 for your average forecast score...

Jane: pretty bad.

Interviewer: what do you think your average score is now toward the end of the semester?

Jane: I'm not too much higher probably like 28 to 32 I haven't gotten a perfect score on a forecast yet...

Interviewer: do you think it's possible to get a perfect forecast score?

Jane: it's possible but I think a lot of it would be... I mean a lot of it's on knowledge but sometimes little glitches... even the best meteorologist don't predict the weather perfectly. I think it's possible to get a perfect score but not entirely likely.

Interviewer: You can't always say ahead of time...

Jane: exactly.

Interviewer: so do you get the impression that the technique you use now is more effective than the one you used before?

Jane: I think so but I haven't seen it payoff yet.

Interviewer: when you say pay off, what do you mean?

Jane: I mean I've been checking my scores lately and I notice that sometimes in the early forecasts when I was just looking at the Weather Channel, my scores were higher than when I was looking at all the scientific maps. Because sometimes they don't get the maps updated and so I'll be predicting for Sunday and they'll still have Saturdays maps up and so I'll be drumming my fingers saying "Ohhhh.... What can I guess here?" or sometimes my computer just won't bring them up, because I'm on a pretty archaic computer. So that's when I have to fill in the gaps and I think I was a better guesser at the beginning than I am now.

Interviewer: so aside from the score you might get a on a given forecast now as opposed to one at the beginning of the semester. Do you recognize some important changes that you've incorporated into your technique that you integrated into your technique because you thought they would help you write more accurate forecast?

Jane: yes I've noticed that I use more sites more religiously. in the past, I only depended on the Weather Channel and sometimes I'd click around to other things, but now I definitely everyday depend on those two basis sites if I don't hit others. And I think that that provides more information. For which I can write my forecast.

Interviewer: and the two sites are the Weather Channel site and the...

Jane: Iowa State site

Interviewer: the mesonet site?

Jane: The thing is, I click on ... it says Iowa State and then to the right of that title it says explanation and analysis and I click on that. Then there's four options and I click on all four and look at the different maps.

Interviewer: now the last set of questions have to do with your major and career goals and some other general questions. Can you tell me what your academic major is right now?

Jane: I'm undecided.

Interviewer: are you leaning toward any....

Jane: but tactically I've already declared AMDP, but in all honesty that was just to get a specific adviser I liked.

Interviewer: what does AMDP stand for?

Jane: apparel merchandising and design production.

Interviewer: which college is that in?

Jane: F C S.

Interviewer: and if you could describe your career goals for when you finish school what do think you want to do?

Jane: ideally I would be on Saturday Night Live because that would be an incredible ideal. Either on the show or as a writer behind the scenes working with the star comedians on their skits. Or a journalist for biographies featured in magazines like rolling Stone or other such things.

Interviewer: are you looking then to become a communications major?

Jane: yes most likely.

Interviewer: Do you have the sense that your career goals will be in any way science related?

Jane: no.

Interviewer: will your career goals have anything to do with meteorology?

Jane: I wanted to be a meteorologist, but when I got into the craft it's a lot more complicated and not as interesting as I was hoping it would be.

Interviewer: now you've almost finished 206 do you think you'll take any other meteorology courses?

Jane: no.

Interviewer: is there any particular reason why?

Jane: because I've gotten a basic understanding and knowledge of how the Weather works
but I don't think I would excel in learning anything further I would just going to class
be swamped not understand and then end up getting a 'D' in the class even giving it
my best effort

Interviewer: OK thanks

APPENDIX O. KATHY RAW DATA

Reflective Activities

Reflective Activity #1

1. 1.
2. I started out by going to the surface maps to look at the temperatures, winds, and fronts. This gave me a look at idea as what I was going to be forecasting. The National Doppler Radar was my next stop because that gives me a good mental picture as to what I will be forecasting. I like to compare what different schools have to say about the weather compared to the weather channel. So I go to the 12 hr and 24 hr forecast temps category. I also go to the 850 mb map for to see what the relative humidity is forecasted to be. After recording all the data on these maps I go to the weather channel. I go to the local weather to see the 7 day forecast. On February 5th, I predicted for there to be no fronts and no clouds. I also predicted there would be no precipitation, so there were no factors for precipitation. I predicted the wind to be at 10 knots out of the west. All of these predictions were correct except my temperatures. My 12Z temp was incorrect. The reason I think this occurred was because I found two completely different lows on the maps I looked at.
3. I don't really have any problems most of the time forecastin. It is just finding the time to sit down and forecast. The only question I seem to come across every time I forecast is why can one school have a completely different forecast then what another school has forecasted?

Reflective Activity #2

1. 27
2. I began by going to ISU, explanation and color analysis. I opened up the map that said temperature and winds. This was so that I could get a feel for what the weather was going to be somewhat like. After this I went to University of Illinois and went under the surface column. This temperature range was about the same as the first one I observed. The final and most helpful place I went to was the weather channel. I began with the local outlook and then the detailed outlook to give me a more exact number. The weather channel influenced me the most, but that is because the other places I looked were approximately in the same range.
3. I began by going to the ISU page and looked at the U.S. weather with fronts map. This said that it was to be partly cloudy. I also went to the NCAR-RAP and looked at the National and Regional Loops. It looked to me that there were going to be clouds somewhat. I ended up making an educated guess about the questions 3 and 9.
4. I began, once again, by going to the ISU page and looked at the temperature and winds map. This gave me a good idea right away that there was not going to be any advection because the winds were not going across the contour lines, they were going more east and west.
5. I went to the ISU page and looked at the U.S. weather with fronts map. There were no fronts even close to Ames, but I thought I should recheck just in case. So, I went to the

University of Illinois page and looked at maps on that page. These maps backed up my declaration of no fronts.

6. My 18Z temperature was incorrect, by one degree. I can not nail down the answer as to why it was incorrect because I used a lot of resources. I just did not put all my information back together correctly. Usually, you can make a well-educated guess with all the information from the maps. I had to make a good prediction about the cloudiness, but I did not succeed with my prediction. I think it is hard to forecast cloudiness when they say partly cloudy because with this you can go either way with your answer. I just need to figure out a better way to forecast cloudiness.
7. As I said before I don't think I am predicting cloudiness correctly. I need to figure out a more reliable resource to refer to when forecasting cloudiness. I can usually forecast the temperature correctly with the process I am using now. My theory is the more maps I observe the better chance I have to be correct. Most of the other things I miss are irregular in what I miss. When I miss a point it usually is in something different all the time.
8. Advection still is not very clear to me, and the adiabatic simulation was a little unclear as well.

Reflective Activity #3

1. 26
2. The Iowa State University page was my first stop. I got some information from the surface temperature map. This map is not very specific, so I usually just use this map as a comparison to the rest of the information I will find. I also visit the University of Wyoming page and go to the Ames airport. I also get a rough guesstimate of the high temperature. I then go to tomorrow a.m. and tomorrow which is under forecast methods on the weather channel. These pages give me a map to observe. Where I get my most accurate information is on the weather channel page. This page is much more exact with their forecasts. There are also much more up to date with their information that is given. I like to go to the hour by hour details that are given.
3. Once again, I start with the Iowa State University weather page. The winds and clouds map help me predict the cloudiness for the next day. I also go to the University of Wyoming page, where I then go to the Ames airport forecast. This gives me another piece of information to compare with what the rest of the pages say. The hour by hour details is the last place I get my information because this gives me a very precise and accurate answer that I can compare with the rest of my answers.
4. After I figure out where the wind is coming from, how strong the wind is, and how fast the temperature changes, I then can figure out advection. I like to use the advection help page that is given to us because I can put all of my answers and find out what type of advection there is, if there is any at all.
5. The Iowa State University surface maps are helpful in seeing there will be any fronts going through the following day. Another very helpful page was tomorrow a.m. and the tomorrow maps on the weather channel's page. These maps show that very obviously there were no fronts on the day that I forecasted.

6. The strategies I have been using for all of answers have always been pretty consistent in having good answers. The only part of forecasting that gets me is predicting if the cloudiness is going to affect the temperature. When it is predicted to be partly cloudy, it is very hard to know if it will effect the temperature. I usually think that it can go either way with the answers. I also think I need to find another way to forecast moisture supply because that answer is also very inconsistent with right or wrong answers.
7. Once again, I think I need to find a more accurate way to forecast moisture supply. I have one page that I always go to, but I should probably go to another page to get more information. This way I can compare the answers that I find. I also think that if I used more time to forecast they might be a little more accurate. I seem to always rush through all of my forecasts and then my answers maybe a little more thorough.
8. I need a more accurate way to answer the question about unstable atmosphere and moisture supply.

Reflective Activity #4

1. 9
2. I only used the weatherchannel when I first started forecasting. I would go and look at the weatherchannel and take that their forecasts for sure. I thought their forecasts were always correct.
3. Now, I double-check all of my forecasts, sometimes I check it with at least a couple of different sites. I like to go to the Iowa State University site and look at the Surface Analysis site. The U.S. weather and fronts is very helpful for fronts because they are very interesting and then I can compare those predictions with the weatherchannels. I also look at the temp and winds page because it gives me a good approximation of the wind speed and direction.
4. I use many of the sites given to me to forecast temperatures. There are many pages you can go to when you are on the weatherchannel site. I like to double check my answers with other universities and the weatherchannel. I think that the people creating the weatherchannel are a little more qualified than students at the universities.
5. I did not predict stability at the beginning of the semester because Darren told us not to worry about it in the winter. Precipitation can be observed at about any site you go to. It kind of just depends on your opinion of the dependabilty at each site. Moisture supply can be predicted with a 850 mb map and 500 mb map. You must subtract these two numbers and if it is 25 or more there will be more than likely moiture supply.
6. I like to look at radars on the weatherchannel because I think it gives the mostaccurate and up-to-date information about precipitation. The ISU page surface analysis fronts also may be able to give you an accurate prediction of what is on the way, in front of or behind a front. The weatherchannel is usually the most reliable source to use on a regular basis.
7. The more you research about precipitation the more accurate you can be. You must try to use as many resources given to you as possible. The resources are there for you, so you might as well take advantage of them.

8. I started with the weatherchannel and whatever it said was right, I thought. I didn't think the weatherchannel was ever incorrect, so I used all of the information that I could find on it. By doing this, it made me look very naive.
9. I now start with the ISU page because I think I have most confidence in the university that is actually there experiencing the weather with me. After visiting this page, I go to the Ohio University page just to get another number or direction to compare with the rest of my information.
10. As in the rest of my forecastin, it is just a lot more thorough now then in the beginning of the semester. I use more resources that are provided for me.
11. Most of my processes would be the same. It just that when I looked at maps I must look about twice as far ahead than normal. I would probably use the weatherchannel a lot because that site has much more information about the future. The weatherchannel forecasts farther in the future for the area code I live in. I think the hardest thing to forecast would be the wind because I believe the wind changes direction and speed very easily and very quick.
12. Please keep giving us tips in class, they are very helpful!

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that our club has developed a fine stable of competition brewers, we are ready for bigger things. Prost!

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To the fine group of fellows who helped me maintain my sanity; JMH, SRV, RC, EC, JimC, BG: Thanks. Also, welcome to the "Insanodome" to: FZ, JW, ET, JC. It is through your musical talents that I was able to filter out the distractions of the world around me and get down to business. Your living ranks are dwindling, but your works continue to speak volumes.

To the three felines that have decided to let us serve them; Squeak, Norton and Oscar: The reason I have been hunched over the keyboard like a troll is now finished. I have been keeping track of both the number and the duration of each of your little "attention grabbers." Believe me, I will get my revenge....

And last, but by no means least, to my loving wife, Jamie: The reason I have been hunched over the keyboard like a troll is now finished. We can now resume our normal lives. Seriously, this has been one of the toughest experiences I have ever had in my life. I know

that sometimes I have not been the nicest guy to be around, especially when Oscar came down to see about the swinging keyboard cable, or to nudge my hand while I was moving the cursor on the screen with the mouse. The constant level of frustration has been numbing at times, and I am overjoyed that you have continued to stick by me. I will never write one of these dastardly things again.

We have had some really great times during this whole experience. I will cherish the fun we had together while we were in Prague, Koeln, Luzern, Hergiswil, the train ride over Domodossola, Bern, Zurich, the train ride that started in 21st century luxury in Luzern, went over Bullet Train efficiency to some little town on the border with Spain, then into “cattle cars,” then the overnight train (on which I almost lost my coat) and Madrid. That trip took us from the 20th Century and into the third millennium (MMI!!!) and then back to the 1940s. And it all happened in four weeks...

Thanks also for breaking it all down for me when I get too worried about incidental things.

It is now time for us to look to the future. As I start my academic career at Towson and you continue your fine career as an elementary überteacher, I know we will do our share to eat all of the seafood in Maryland. I swear you will love it as much as I will. It will be a great adventure, and the TRIUMVIRATE is already excited about it...

I know I will be there for you as you have been there for me. All my love.